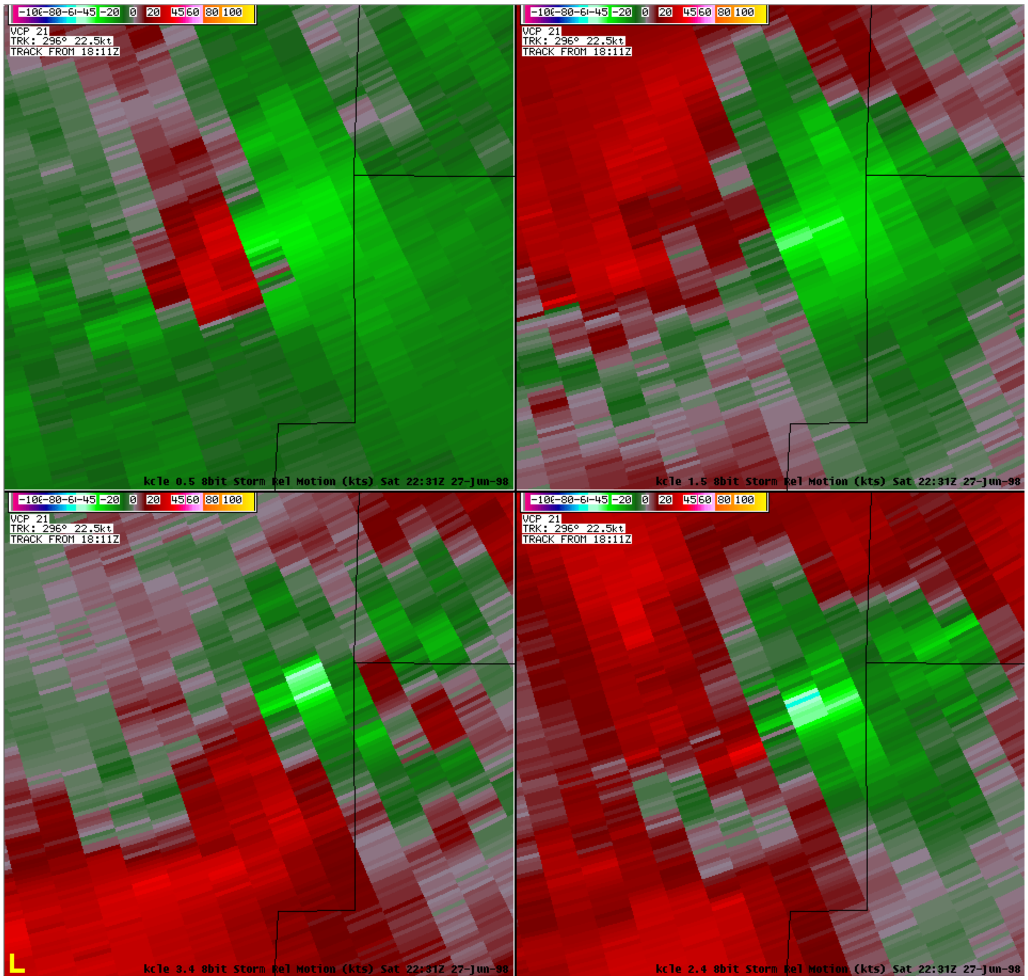
Distance Learning Operations Course



Topic 5: Base and Derived Products

Presented by the

Warning Decision Training Branch

Version: 0508

Table of Contents

Base and Derived Products

Preface

Overview

Welcome to *Base and Derived Products*! This Student Guide is to be used during the *Base and Derived Products* teletraining session. You should place this in your DLOC student binder. This Student Guide not only contains materials presented in the teletraining presentations, but also practice exercises, and supplemental materials. To most effectively learn the material, it is strongly suggested that after attending teletraining, you do the worksheets and exercises in this Student Guide. After completing the practice exercises, you may want to review this Student Guide before attempting the exam.

Prior to taking the exam, you should be comfortable with the objectives listed in each of the five lessons of this Student Guide, as well as the answers to review exercises. Worksheets are also provided for those who want a little extra practice.

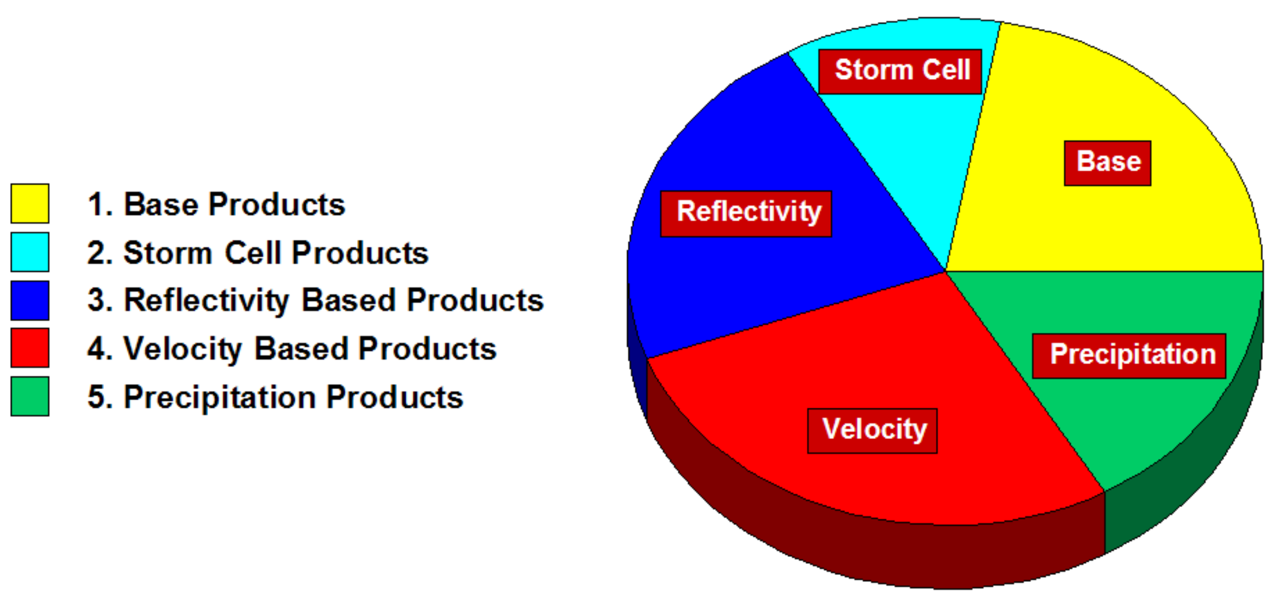


Figure 5-1. List of the 5 lessons in Topic 5 and an approximate breakdown of the time spent on each lesson.

Topic 5 Objectives

1. Identify specific characteristics of WSR-88D products.
2. Identify limitations of WSR-88D products.
3. Identify specific applications (strengths) of WSR-88D products.

Review

Analog data are sent from Receiver to Signal Processor, and converted to digital base data at the Signal Processor.

Clutter suppression and some range unfolding are completed at the RDA and digital base data is then sent to the RPG via wideband link.

Velocity dealiasing and some additional range unfolding (in VCP 12 and 121) is done at the RPG, then product generation occurs. Products are then sent from the RPG to AWIPS (see Fig. 5-2).

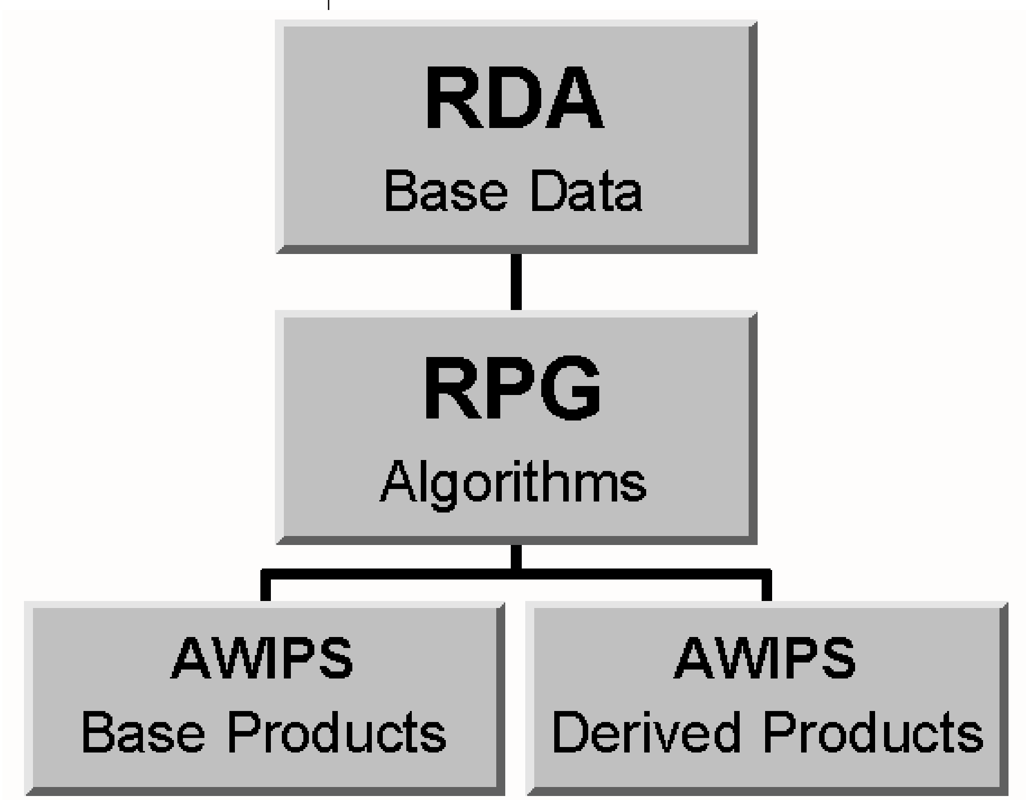


Figure 5-2. Base Data (Reflectivity, Velocity, and Spectrum Width) is sent from the RDA to the RPG where the radar products are produced and sent to AWIPS and other users.

Base Products vs Derived Products

Base Products are those that display the three base moments -- reflectivity (Z or R), velocity (V), and spectrum width (SW). All other WSR-88D products are called Derived Products. Derived Products use meteorological algorithms (computer programs) residing in the RPG or AWIPS to manipulate the base data.

Why use Base Products?

Base products are preferred for analyzing significant meteorological features. Derived products tend to remove or mask many types of important signatures. Base products can be used to determine significant synoptic and mesoscale features, such as fronts and other boundaries, weak echo regions, and heavy snow bands.

Why use Derived Products?

Derived products can assist the user in rapidly analyzing data. It is important to note that the Derived Products are only as good as the algorithms (computer programs) that produce them. Decisions should **never** be based solely on Derived Products. The Derived Products should be used like other types of computer guidance (i.e., MOS).

Using both Base and Derived Products

When possible, base products should be used to verify features found in derived products. When you look at a base product, you are seeing the data used as input for all the derived products, and can use this data to evaluate the derived products. For example, is that heavy precipitation area on the One Hour Precipitation (OHP) product from rain, or from the bright band? At what altitude is the higher reflectivity occurring on the Composite Reflectivity?

More on Base Products

All base products are displayed as a polar coordinate (360° azimuth) color image at approximately one degree beamwidth. Base Products are relative to the RDA. The beam always originates from the RDA and not the location of the operator, or the RPG.

Base products are available for any elevation angle of the current VCP in effect. If the radar is in VCP 12, products are available for all 14 elevation angles. If VCP 31 is current, then only 5 elevation angles are available.

More on Derived Products

The meteorological algorithms used by the WSR-88D vary considerably in their complexity. The numerical manipulations in some algorithms are very complex, while others are simple. Many algorithms become more complex as certain criteria are met.

Adaptable Parameters

It has long been recognized that in different climatological regimes, adjustments may need to be made to the meteorological algorithms. The values (parameters) within an algorithm that can be changed are called the Adaptable Parameters.

There are hundreds of meteorological adaptable parameters in the WSR-88D. Since changing an adaptable parameter may have unexpected results on algorithm output, most meteorological adaptable parameters are ROC controlled, meaning that you do not have the authority to change a value without ROC approval. Almost all of the meteorological adaptable parameters that can be changed at the RPG HCI are password protected. (See Fig. 5-3 on page 5-15.)

Derived Product Menus

In general, derived products that are icons (Storm Tracking, Hail Index, Mesocyclone, TVS, etc. are found on ***kxxx Graphics*** submenu. Derived products that are images are found on the ***kxxx Derived*** menu. (See Fig. 5-4 on page 5-15.)

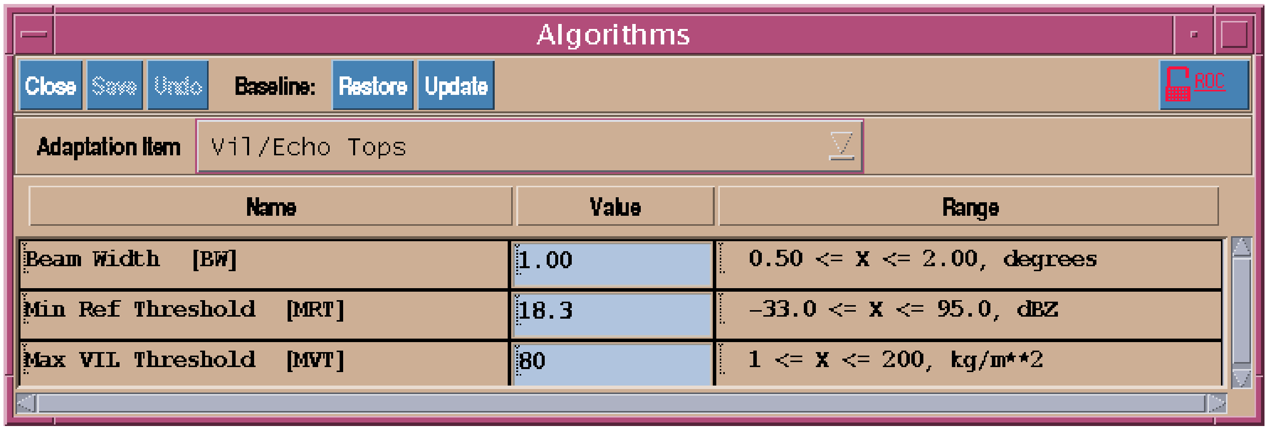


Figure 5-3. Here is an example of adaptable parameters within the VIL algorithm (RPG HCI).

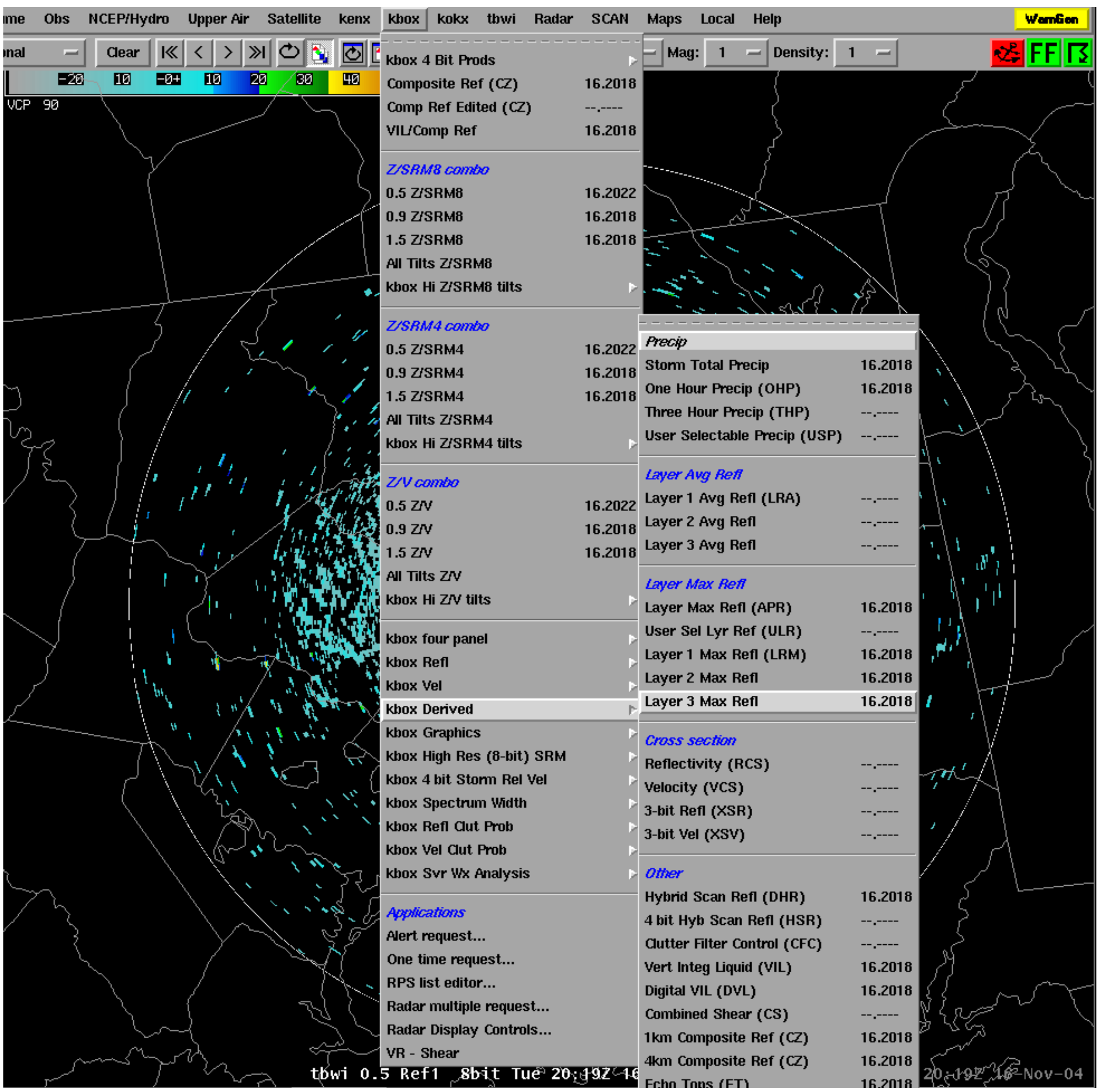


Figure 5-4. Derived products are found on several menus on the AWIPS Workstation.

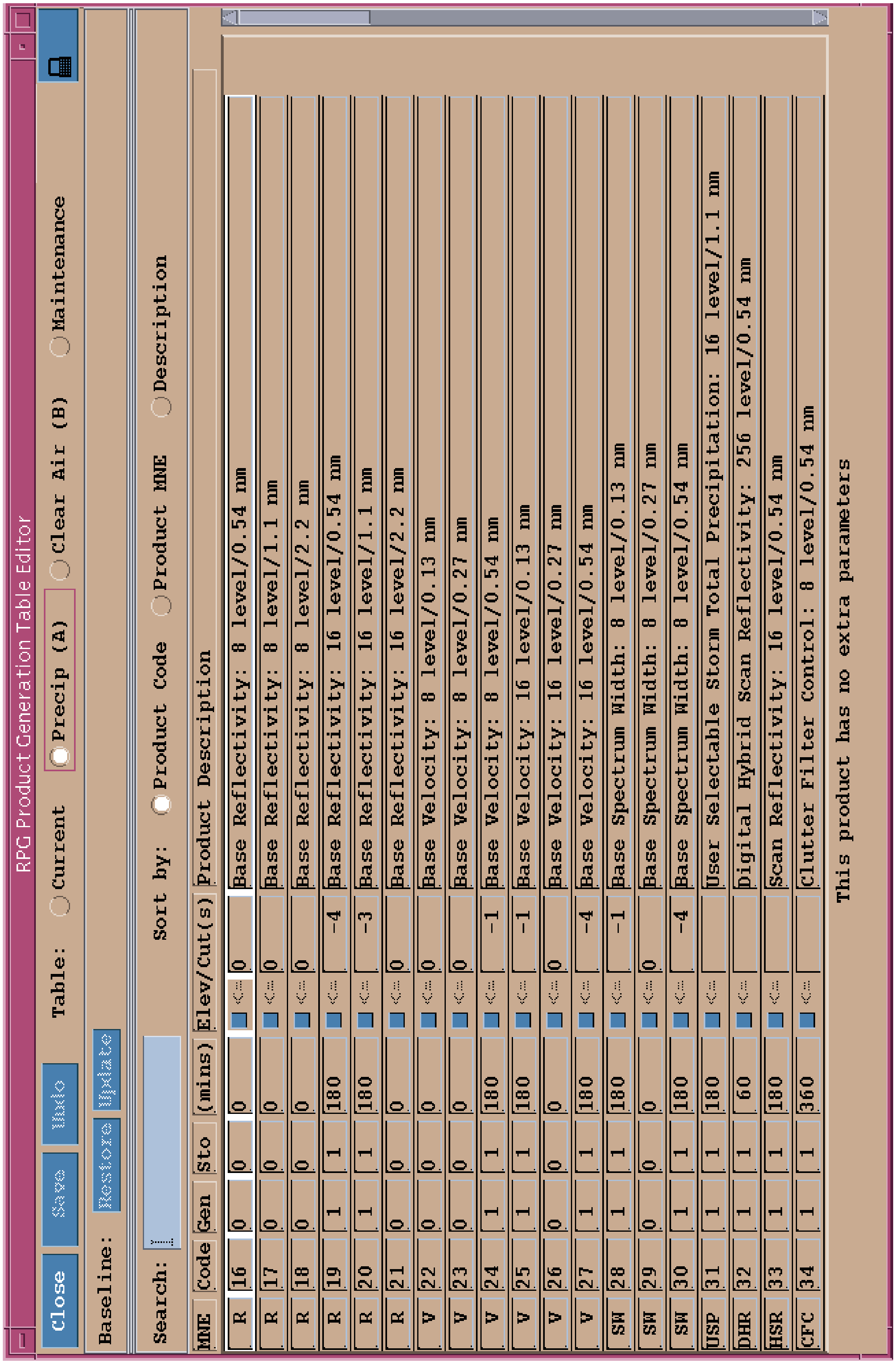


Figure 5-5. Products 16-34

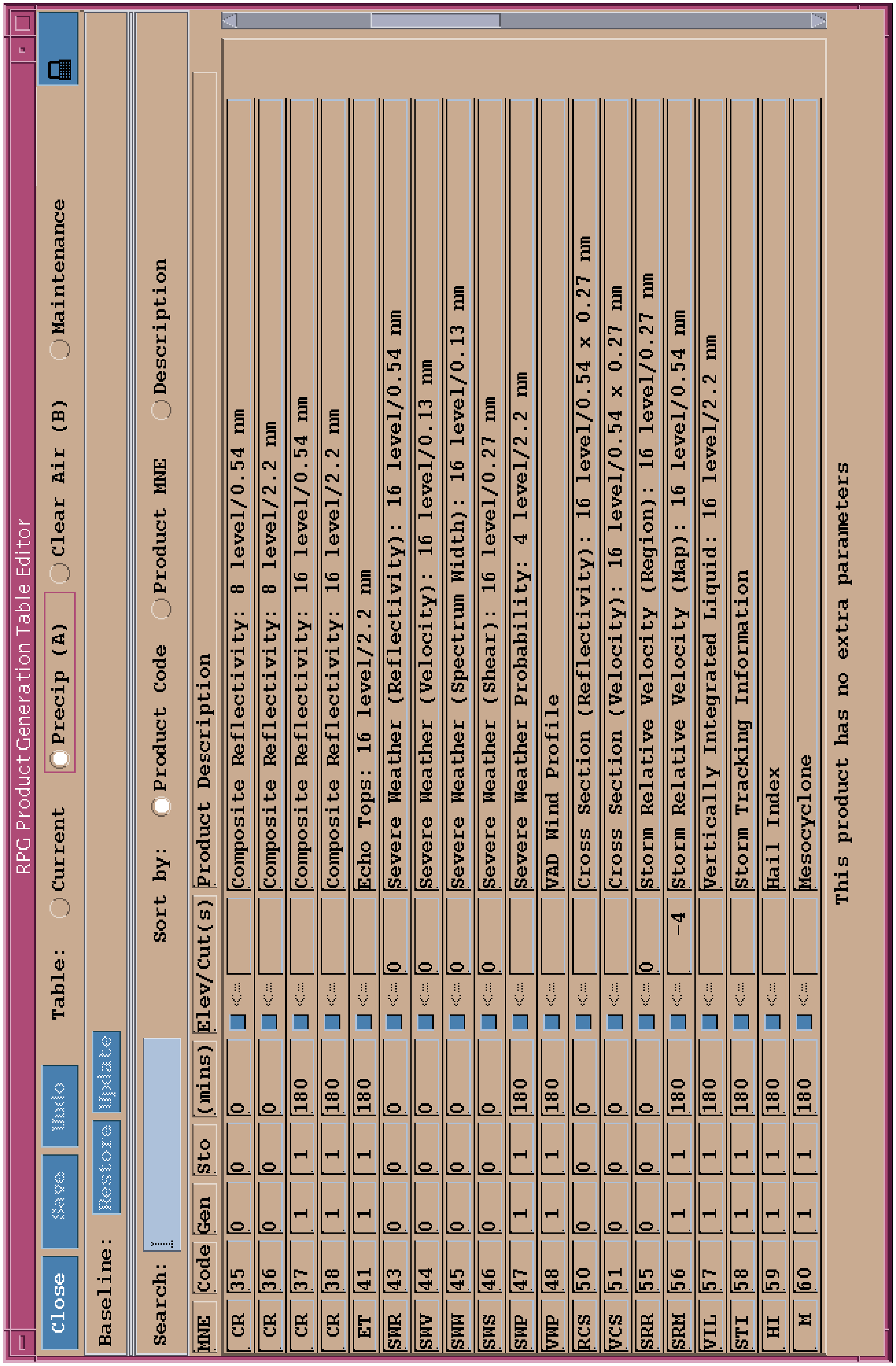
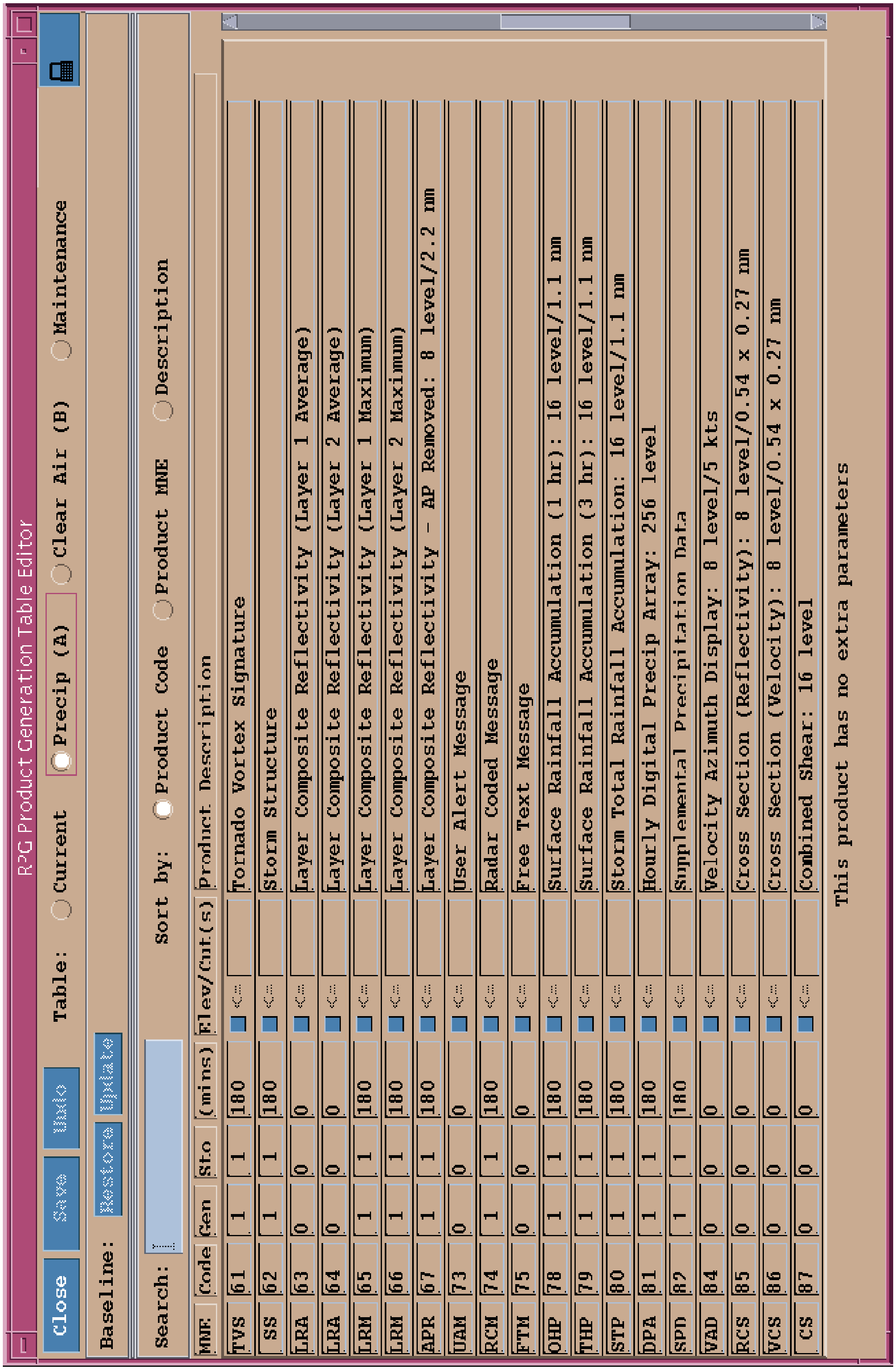
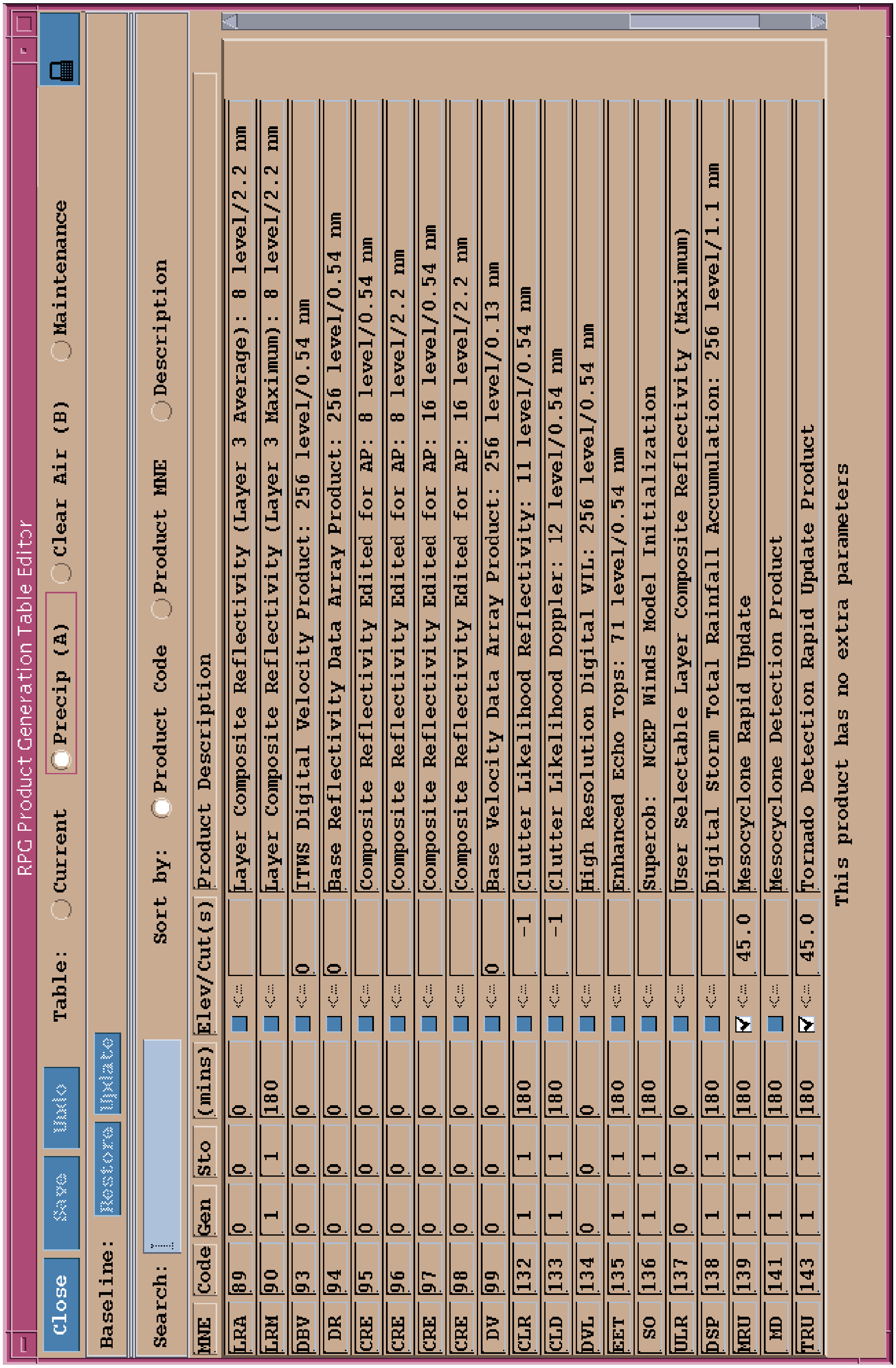


Figure 5-6. Products 35-60



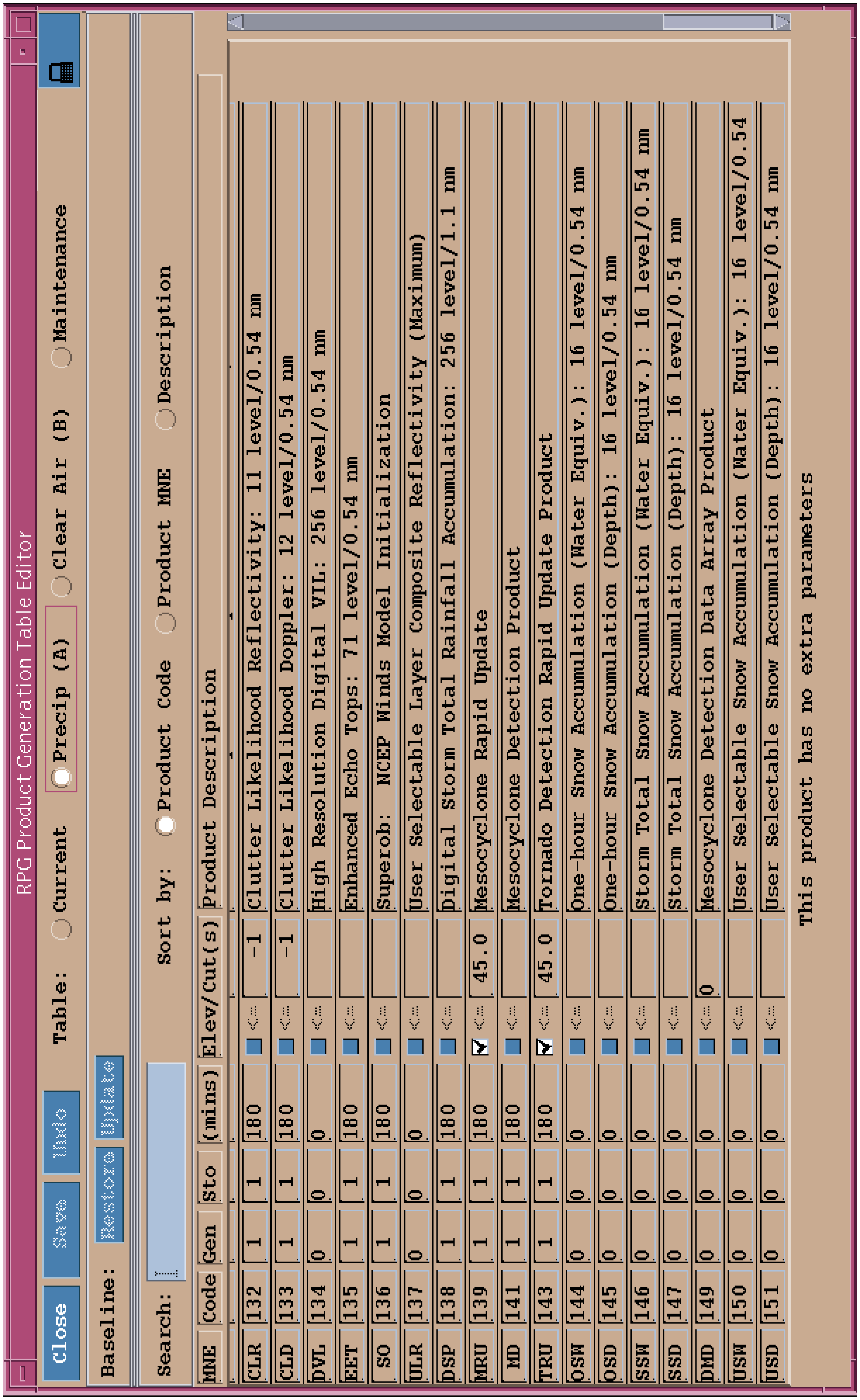
MNE	Code	Gen	Sto	(mins)	Elev/Cut(s)	Product Description
TVS	61	1	1	180	<=	Tornado Vortex Signature
SS	62	1	1	180	<=	Storm Structure
LRA	63	0	0	0	<=	Layer Composite Reflectivity (Layer 1 Average)
LRA	64	0	0	0	<=	Layer Composite Reflectivity (Layer 2 Average)
LRM	65	1	1	180	<=	Layer Composite Reflectivity (Layer 1 Maximum)
LRM	66	1	1	180	<=	Layer Composite Reflectivity (Layer 2 Maximum)
APR	67	1	1	180	<=	Layer Composite Reflectivity - AP Removed: 8 level/2.2 nm
UAM	73	0	0	0	<=	User Alert Message
RCM	74	1	1	180	<=	Radar Coded Message
FTM	75	0	0	0	<=	Free Text Message
OHP	78	1	1	180	<=	Surface Rainfall Accumulation (1 hr): 16 level/1.1 nm
THP	79	1	1	180	<=	Surface Rainfall Accumulation (3 hr): 16 level/1.1 nm
STP	80	1	1	180	<=	Storm Total Rainfall Accumulation: 16 level/1.1 nm
DPA	81	1	1	180	<=	Hourly Digital Precip Array: 256 level
SPD	82	1	1	180	<=	Supplemental Precipitation Data
VAD	84	0	0	0	<=	Velocity Azimuth Display: 8 level/5 kts
RCS	85	0	0	0	<=	Cross Section (Reflectivity): 8 level/0.54 x 0.27 nm
VCS	86	0	0	0	<=	Cross Section (Velocity): 8 level/0.54 x 0.27 nm
CS	87	0	0	0	<=	Combined Shear: 16 level

Figure 5-7. Products 61-87



MNE	Code	Gen	Sto	(mins)	Elev/Cut(s)	Product Description
LRA	89	0	0	0		Layer Composite Reflectivity (Layer 3 Average): 8 level/2.2 nm
LRM	90	1	1	180		Layer Composite Reflectivity (Layer 3 Maximum): 8 level/2.2 nm
DBV	93	0	0	0	0	ITWS Digital Velocity Product: 256 level/0.54 nm
DR	94	0	0	0	0	Base Reflectivity Data Array Product: 256 level/0.54 nm
CRE	95	0	0	0		Composite Reflectivity Edited for AP: 8 level/0.54 nm
CRE	96	0	0	0		Composite Reflectivity Edited for AP: 8 level/2.2 nm
CRE	97	0	0	0		Composite Reflectivity Edited for AP: 16 level/0.54 nm
CRE	98	0	0	0		Composite Reflectivity Edited for AP: 16 level/2.2 nm
DV	99	0	0	0	0	Base Velocity Data Array Product: 256 level/0.13 nm
CLR	132	1	1	180	-1	Clutter Likelihood Reflectivity: 11 level/0.54 nm
CLD	133	1	1	180	-1	Clutter Likelihood Doppler: 12 level/0.54 nm
DVL	134	0	0	0		High Resolution Digital VIL: 256 level/0.54 nm
EET	135	1	1	180		Enhanced Echo Tops: 71 level/0.54 nm
SO	136	1	1	180		Superob: NCEP Winds Model Initialization
ULR	137	0	0	0		User Selectable Layer Composite Reflectivity (Maximum)
DSP	138	1	1	180		Digital Storm Total Rainfall Accumulation: 256 level/1.1 nm
MRU	139	1	1	180	45.0	Mesocyclone Rapid Update
MD	141	1	1	180		Mesocyclone Detection Product
TRU	143	1	1	180	45.0	Tornado Detection Rapid Update Product

Figure 5-8. Products 89-143



MNE	Code	Gen	Sto	(mins)	Elev/Cut(s)	Product Description
CLR	132	1	1	180	-1	Clutter Likelihood Reflectivity: 11 level/0.54 nm
CLD	133	1	1	180	-1	Clutter Likelihood Doppler: 12 level/0.54 nm
DVL	134	0	0	0		High Resolution Digital VIL: 256 level/0.54 nm
EET	135	1	1	180		Enhanced Echo Tops: 71 level/0.54 nm
SO	136	1	1	180		Superob: NCEP Winds Model Initialization
ULR	137	0	0	0		User Selectable Layer Composite Reflectivity (Maximum)
DSP	138	1	1	180		Digital Storm Total Rainfall Accumulation: 256 level/1.1 nm
MRU	139	1	1	180	45.0	Mesocyclone Rapid Update
MD	141	1	1	180		Mesocyclone Detection Product
TRU	143	1	1	180	45.0	Tornado Detection Rapid Update Product
OSW	144	0	0	0		One-hour Snow Accumulation (Water Equiv.): 16 level/0.54 nm
OSD	145	0	0	0		One-hour Snow Accumulation (Depth): 16 level/0.54 nm
SSW	146	0	0	0		Storm Total Snow Accumulation (Water Equiv.): 16 level/0.54 nm
SSD	147	0	0	0		Storm Total Snow Accumulation (Depth): 16 level/0.54 nm
DMD	149	0	0	0	0	Mesocyclone Detection Data Array Product
USW	150	0	0	0		User Selectable Snow Accumulation (Water Equiv.): 16 level/0.54
USD	151	0	0	0		User Selectable Snow Accumulation (Depth): 16 level/0.54 nm

Figure 5-9. Products 132-151

Lesson 1: Base Products

Objectives

Upon completion of this lesson, you will be able to:

1. Identify specific characteristics of any Base Product.
2. Identify limitations of any Base Product.
3. Identify specific applications (strengths) of any Base Product.

Base Product Color Depth - Data Levels

Base products are available in three different “color depths” each corresponding to a different number of data levels:

- 8-bit = 256 data levels
- 4-bit = 16 data levels
- 3-bit = 8 data levels

Generally, the more data levels the better. Then why have 4-bit and 3-bit base products? The answer lies in file size. The 8-bit (256 data levels) base product files are 4 to 10 times larger than 4-bit (16 data levels) base product files. Therefore, it takes the 8-bit products longer to be transmitted from the RPG to users. If there is a high speed connection, such as the LAN connection between the RPG and co-located AWIPS, numerous 8-bit base products can be made available. For slower speed connections, such as dial-up modems, one 8-bit product can take several minutes to transmit.

In AWIPS, when selecting “Refl” from the menu, the 8-bit product will be displayed if it is in the database. The 4-bit and 3-bit base products are on separate menus (see figure 5-12 on page 24). Note that some VCP 12 elevation slices are not on the menu. Selection of the closest value will display those elevation slices (e.g., selection of 3.4 Refl will display 3.2 degree product).

Base Reflectivity (Z)

Example Fig. 5-10 on page 22.

8-Bit Base Reflectivity Product Characteristics

8-bit Reflectivity Resolution - 0.54 nm x 1 degree To generate this data, the power from four successive 0.13 nm bins is averaged. This average power is then converted to dBZs at the RDA. After the base data is created, it is transmitted to the RPG via the wideband link. The 8-bit Reflectivity

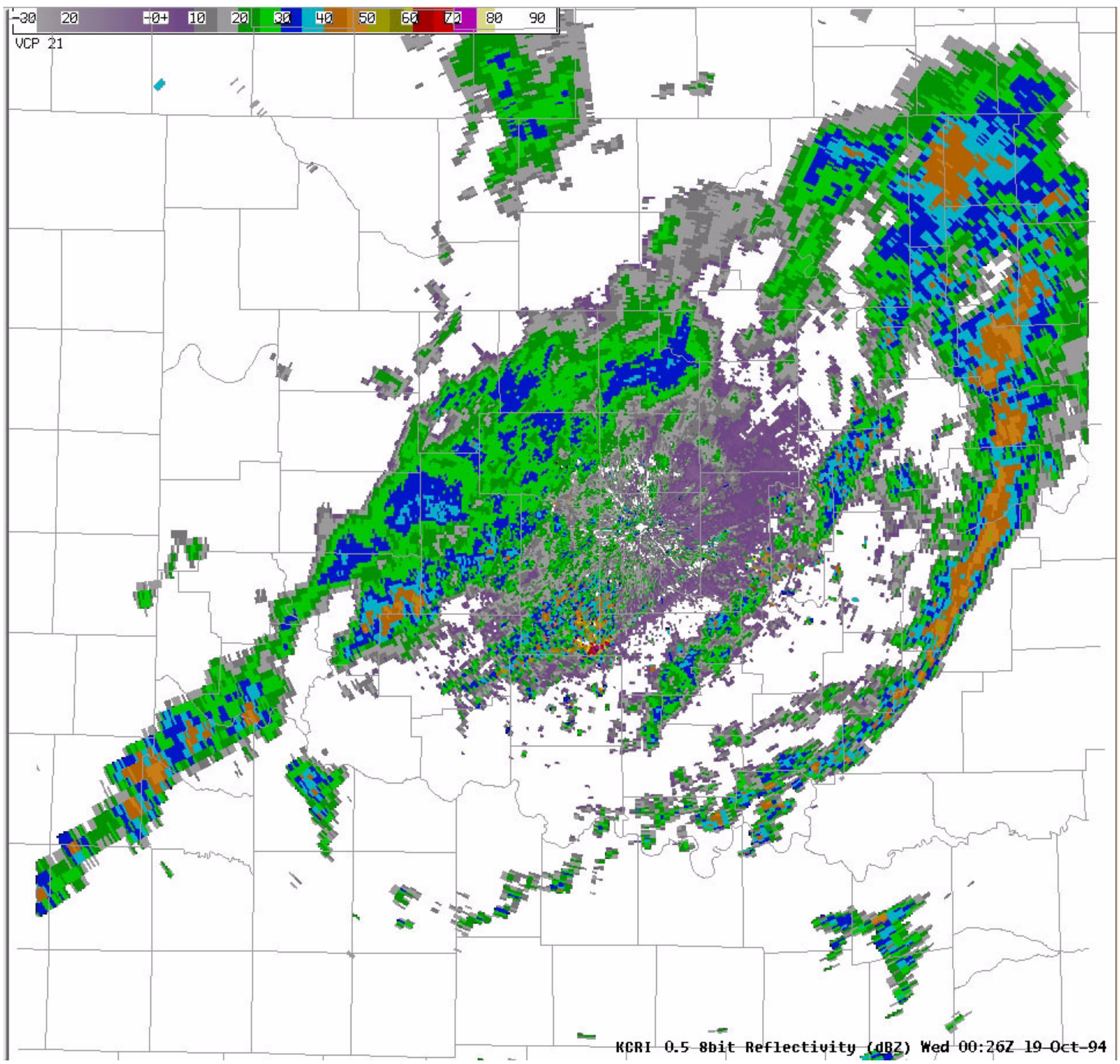


Figure 5-10. This 8-bit Reflectivity product has a maximum range of 248 nm. The resolution is 0.54 nm out to 248 nm. (.54 nm is the only resolution available for the 8-bit Reflectivity product)

products produced by the RPG display at 0.54 nm resolution to 248 nm.

8-bit Reflectivity Range - 248 nm

8-bit Reflectivity Data Levels- All VCPs

- 256 Data Levels: -30 dBZ to >90 dBZ
- To the nearest 0.5 dBZ

8-bit Ref product legend description:

- RPG ID: kxxx
- ELEVATION ANGLE: x.x in degrees (see Fig. 5-11)
- PRODUCT NAME: 8-bit Reflectivity
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

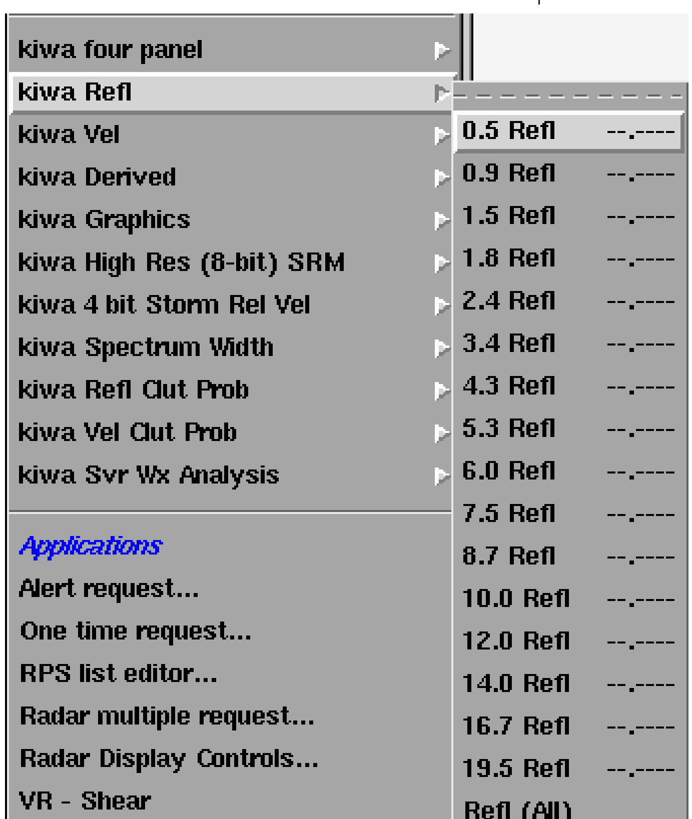


Figure 5-11. 8-bit Reflectivity product menu. Some VCP 12 elevation slices are not on menu. Selection of the closest value will display those elevation slices (e.g., select 3.4 Refl displays 3.2^{o} product)

8-bit Ref product annotations:

- VCP: 11, 12, 21, 121, 31 or 32
- Product Resolution: 1 km (0.54 nm)

4-Bit and 3-Bit Base Reflectivity

The 4-bit (16 data level) and 3-bit (8 data level) base reflectivity products are available at 3 resolutions of 1 degree beamwidth:

- **0.54 nm** (1 km) to 124 nm range
- **1.1 nm** (2 km) to 248 nm range
  - •• Displays maximum of two consecutive 0.54nm data values
- **2.2 nm** (4 km) to 248 nm range
  - •• Displays maximum of four consecutive 0.54nm data values

Selecting a 4-bit or 3-bit reflectivity product in AWIPS(see Fig. 5-12) will display the best resolu-

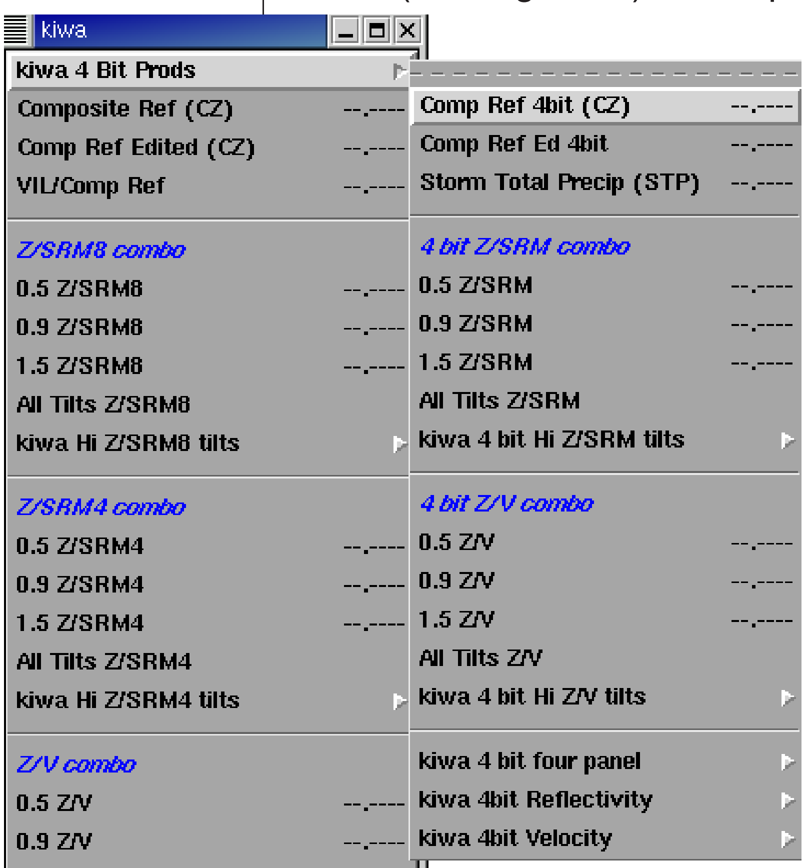


Figure 5-12. 4Bit Product Menu

tion product available in the AWIPS data base. For instance, if both the 0.54 nm resolution product and the 1.1 nm product are in the AWIPS database, the display will have 0.54 nm x 1° data out to 124 nm and 1.1 nm x 1° resolution data from 124 nm out to 248 nm.

See Figure 5-13 for an example of a 4-bit (16 data level) Base Reflectivity product.

Implications to the operator

Both 4-bit or 3-bit reflectivity products in AWIPS will display a resolution change at 124 nm range from 0.54 x 1° to 1.1 nm (or 2.2 nm) x 1° (see Fig. 5-13).

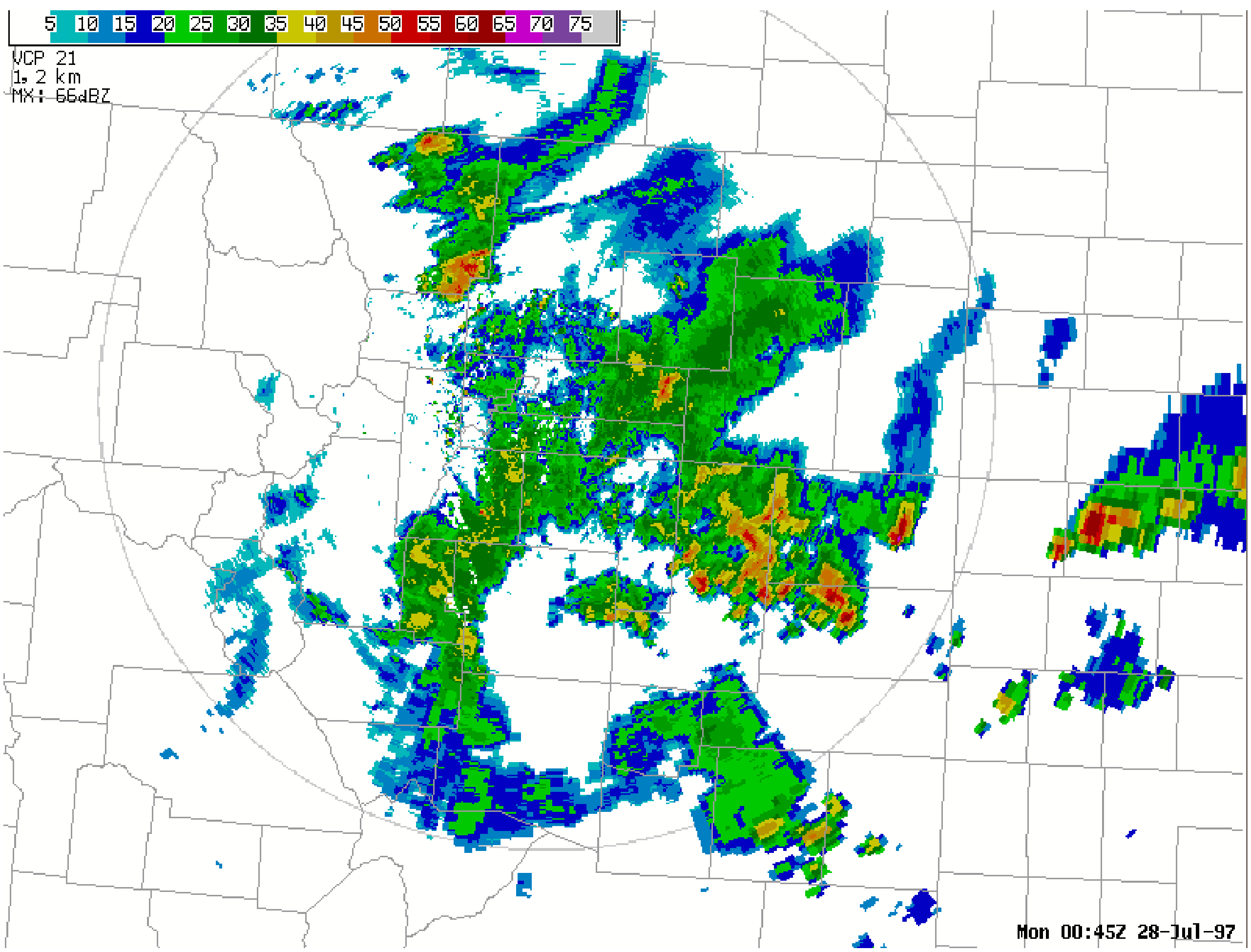


Figure 5-13. Example of displayed resolution differences on a Base Reflectivity product. The 0.54 nm and 1.1 nm resolutions are displayed.

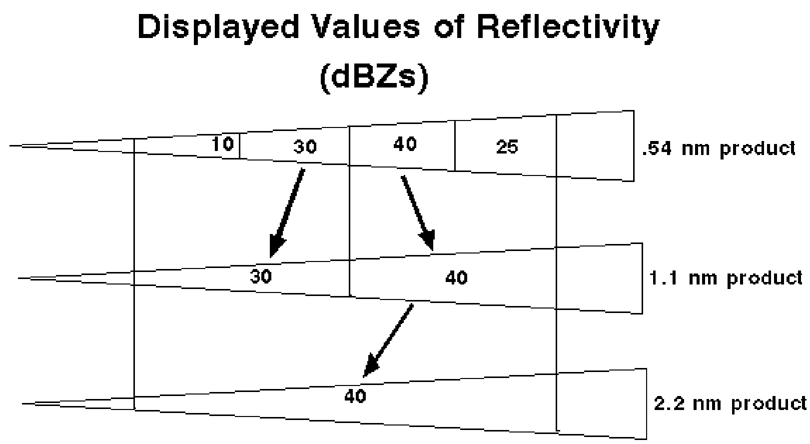


Figure 5-14. Values of reflectivity retained for display on products of different resolutions.

Maximum reflectivity is always displayed as resolutions change, preserving important meteorological features (storm cores, etc.). See Figure 5-14.

4-Bit and 3-Bit Data Levels

Clear Air Mode (Mode B) VCPs 31 and 32

16 Data Levels range from -28 dBZ to ≥ 28 dBZ
8 Data Levels range from 5 dBZ to ≥ 57 dBZ

Precipitation Mode (Mode A) VCPs 11, 12, 21, 121

16 Data Levels range from 5 dBZ to ≥ 75 dBZ
8 Data Levels range from 5 dBZ to ≥ 57 dBZ

The data level range of the 3-bit (8 data level) base reflectivity products do not change with VCP changes. Only the 4-bit (16 data level) base reflectivity products change data level values when changing between Precipitation Mode and Clear Air Mode (See Fig. 5-15 on page 27.)

Data levels are displayed using lower bound thresholds. This means that the numbers beside the color bar in the annotations area of the product are the lowest dBZ values for each color. The color labeled 35 dBZ actually ranges from 35-39 dBZ.

The maximum reflectivity (dBZ) is noted in the product annotation area and may occur anywhere in the product. The location of the maximum reflectivity is **not** displayed.

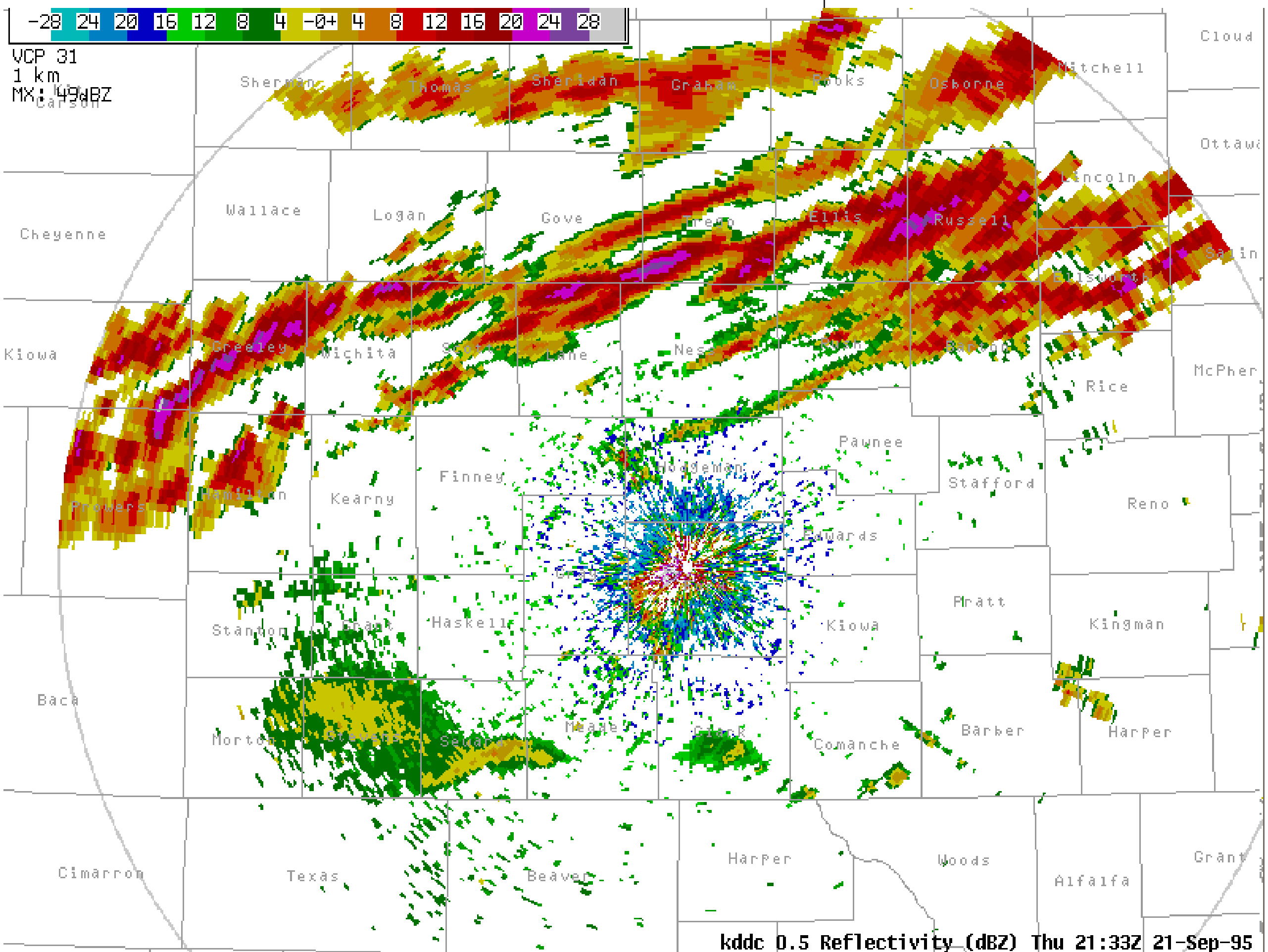


Figure 5-15. Clear Air Mode 4-bit (16 data level) Reflectivity Product.

Base Reflectivity Limitations

1. Ground Returns

- Residual clutter and ground returns from superrefraction may contaminate products.

Operational Solutions

- Invoking clutter suppression at the RPG HCI should be the first action an operator takes to reduce ground returns. Base Products can be used to evaluate the Base Data that is being used in all the algorithms. Ground returns not only make Base Products hard to interpret, but they can also contaminate the derived products.

- Viewing a higher elevation angle will display data that was sampled above the ground returns.
- An adjacent radar site may not be experiencing superrefraction. Requesting products from that site will help the operator view an area of interest without contamination from AP.

2. Beam Blocking

- Beam blocking is possible especially on lower elevation angles. When sites for the radars were chosen, one of the considerations was to minimize blockage of the beam. Unfortunately, that is not possible at every radar site.

Operational Solution

- Solutions to beam blockage are choosing a higher elevation angle to overshoot the target that is blocking the radar beam, or requesting products from an adjacent site to view the areas that are being obscured.

3. Resolution vs. Range

- Beam broadening leads to poor resolution at longer ranges.

Operational Solution

- Call another site closer to the return.

4. Effects of Earth Curvature

- Beam centerline increases in altitude with range. The radar may then overshoot significant features at low levels and far ranges.

Operational Solution

- Access a closer radar that samples the feature at lower altitudes. Be aware of the importance of spotter input at these far ranges.

5. Effects of Discrete Elevation Sampling

- Echoes may be poorly sampled by the VCP in use depending on range and echo geometry. A small storm at far ranges will be poorly sampled compared to the same storm close in. In addition, a close storm will be more poorly sampled in VCP 21 than VCP 12.

Operational Solution

- If possible, operate in VCP 12 when echoes are present. This VCP will better sample storms both at far and near ranges.
- Accessing other radars may show the same storm at different altitudes.

6. Cone of Silence

- Data are unavailable for higher altitudes close to the RDA. The highest elevation angle is 19.5^{o} in VCPs 11, 12 and 21 and 121. Data above 19.5^{o} is not available for display on any of the Base Products.

Operational Solution

- If applicable, request Base Products from an adjacent site to display data in the cone of silence where data are needed.

7. Chaff

- Chaff consists of many very small fibers typically dropped from military aircraft to camouflage the aircraft from radar detection. Chaff may cause large areas of non-meteorological echoes. The radar echo typically begins as a small area of 20 to 40 dBZ echoes. These returns can resemble pulse type thunderstorms. Over time, the chaff will spread out with the mean wind flow both horizontally and vertically. The radar echo becomes elongated and slowly decreases in intensity.

Operational Solution

- Review all types of observation systems to make a determination on chaff. Satellite, surface observations, other radar sites, and spotters are tools that can be used.
- Watch for high dBZ during initial release, with gradual decrease in intensity, spreading with mean wind flow, and vertical dispersion.
- Look for reoccurrence over the same areas upwind of flight routes, military operations areas etc.
- Military points of contact are often unable to disclose chaff drops. During an exercise the decision may be up to the pilot to drop chaff, and is not necessarily a coordinated scheduled chaff release.

Base Reflectivity Product Applications (Strengths)

1. **Observe precipitation intensity, movement and trends.**
   - Base reflectivity has been the standard output from radars for the past 50 years, and remains one of the most useful outputs from the WSR-88D.
   - Precipitation products use base reflectivity. Reflectivity products can be used for validation and quality control of precipitation products.
   - The use of Clear Air Mode can be useful during winter storm events with better detection of snow than in Precipitation Mode.
2. **Determine significant storm structure features.**
   - Several storm structure features can be readily identified using base products including Weak

Echo Regions (WER), Bounded Weak Echo Regions (BWER), hooks, Three Body Scatter Spikes (TBSS), Rear-Inflow Jet or Weak echo channels, and differing supercell characteristics just to name a few.

3. **Determine location and motion of fronts and other boundaries**.
   - 8-bit 0.5 degree base products are the best radar products to use for boundary detection.
   - Finelines on base reflectivity products indicate boundaries such as gust fronts.
   - If possible, use Clear Air Mode for increased sensitivity. Base Reflectivity in clear air mode will display reflectivities down to -30 dBZ, allowing the operator to see features with low returns such as fronts and drylines.
4. **Locate and identify the melting level.**
   - A melting level of uniform height can be identified as a ring, or partial ring, of slightly higher reflectivity values in the Reflectivity product. If the height of the melting level varies with range from the radar, the ring will be asymmetric and/or the melting level may appear as an arc or as an irregular band.
5. **Identify non-meteorological phenomena.**
   - Many non-meteorological phenomena can be detected on the radar. Bird, bat and insect flight patterns may be viewed. The radar can be used to track range fires as well as locate possible areas where forest fires have started. Furthermore, the radar will be useful to locate volcanic ash, airplanes, chaff droppings and even speeders on the highway. As an operator, you must be constantly aware of the potential for non-meteorological phenomena detection. Remain alert and always use all resources possible to make a determination on what you are viewing.

Base Mean Radial Velocity (V)

8-Bit Base Velocity Product Characteristics

See Figure 5-16 on page 33.

8-bit Velocity Resolution - 0.13 nm x 1 degree

8-bit Velocity Range - 124 nm.

8-bit Velocity Data Levels - All VCPs

- 256 Data levels: > 100 kts inbound/outbound
- Negative values represent inbound velocities
- Positive values represent outbound velocities

8-bit Velocity product legend description:

- RPG ID: kxxx
- ELEVATION ANGLE: x.x in degrees
- PRODUCT NAME: 8-bit Velocity
- UNITS: kts
- DATE: Day of week, time, and date in UTC8-bit Velocity product annotations:
- VCP: 11, 12, 21, 121, 31 or 32
- Product Resolution: 0.25 km
- MN - Minimum (inbound): xx kts
- MX - Maximum (outbound): xx kts

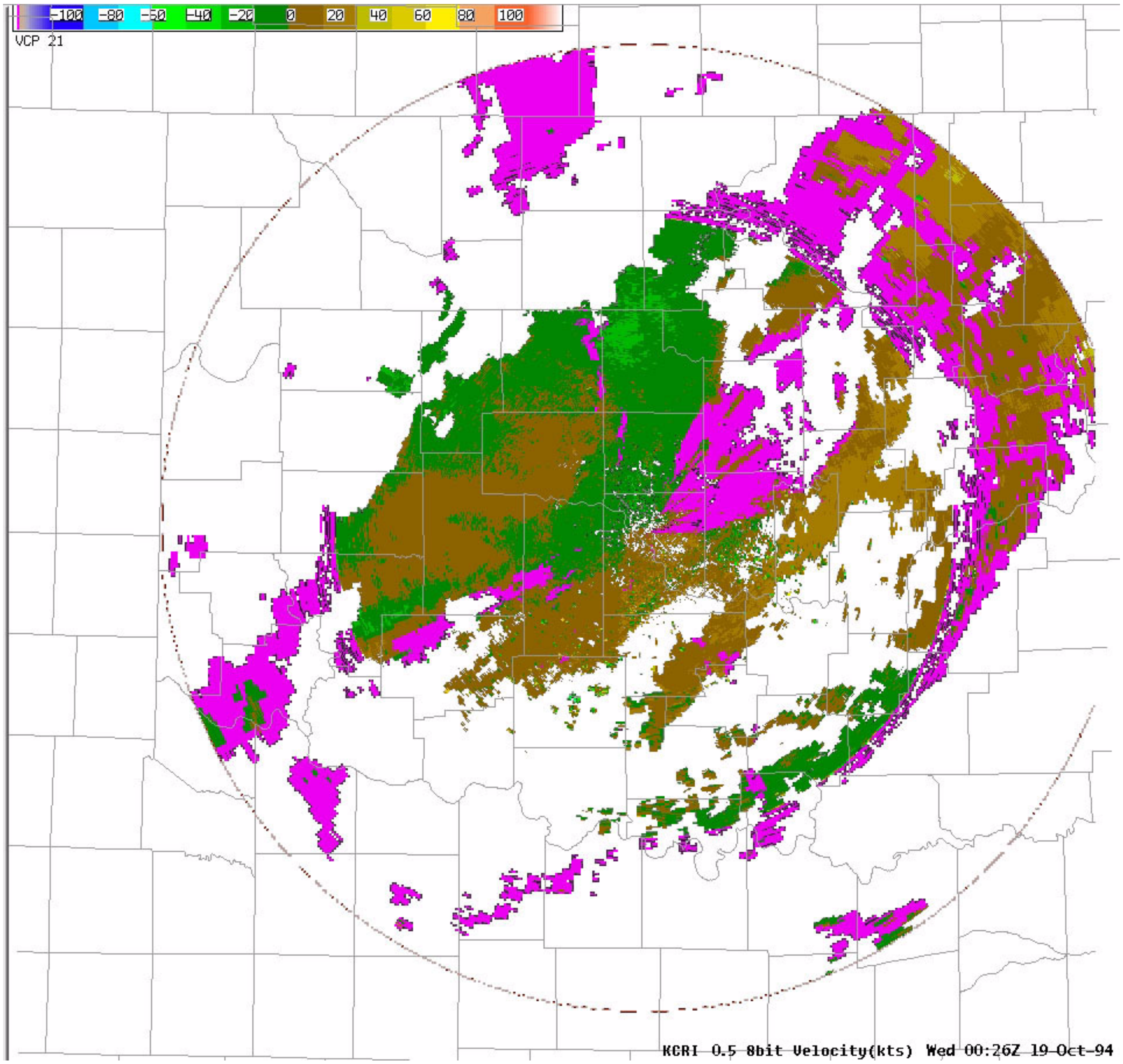


Figure 5-16. This 8-bit Velocity product has a maximum range of 124 nm. The resolution is.13 nm out to 124 nm. (.13 nm is the only resolution available for the 8-bit Velocity product)

Velocity increment

For velocities less than 124 kts, an increment of 0.97 kts can be invoked at the RPG HCI. This allows the display of velocities up to +/-123 kts in one kt increments. To display velocities up to 246 kts, the velocity increment of 1.94 kts must be invoked at the RPG HCI. This allows the display of velocities up to +/-246 kts in two kt increments.

4-bit and 3-bit Base Velocity

The 4-bit (16 data level) and 3-bit (8 data level base velocity products are available at three resolutions to three ranges(see Fig. 5-17):

- 0.13 nm (0.25 km) x 1° to 32 nm
- 0.27 nm (0.5 km) x 1° to 62 nm
- 0.54 nm (1.0 km) x 1° to 124 nm

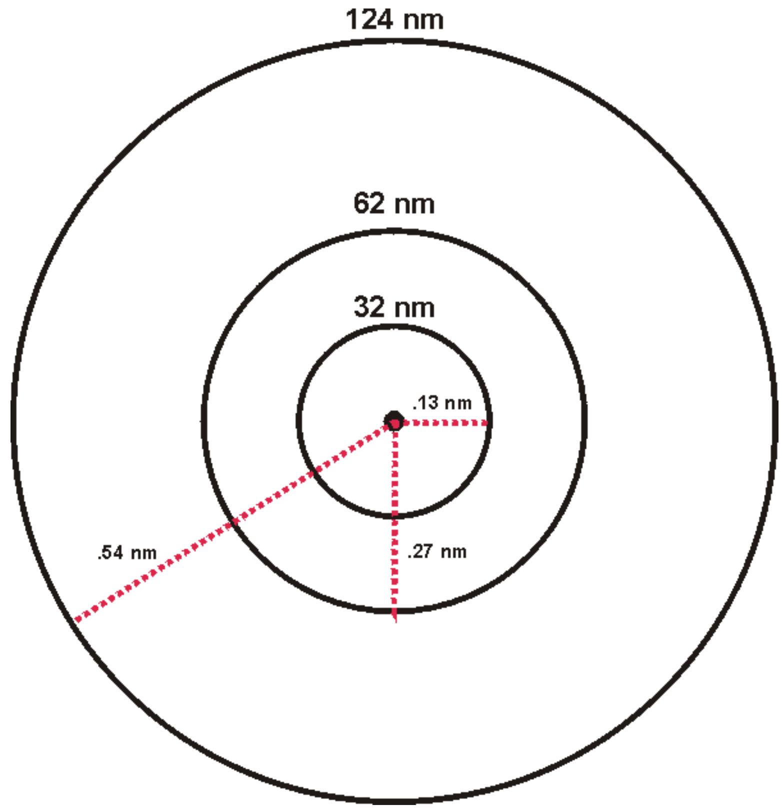


Figure 5-17. AWIPS display of 4-bit and 3-bit Base Velocity uses three different resolutions as available.

Generation

Figure 5-18 shows the method of choosing which data value will be used for display at lower resolutions. The 0.13 nm resolution product displays all 0.13 by 1° data. For the 0.27 nm resolution product the first of two consecutive 0.13 nm data values is displayed. The 0.54 nm resolution product displays the first of four consecutive 0.13 nm data values.

As seen in Figure 5-18, because of this display method, echoes on these products will appear differently at various ranges with different resolutions. In contrast to reflectivity, even though the maximum velocity and spectrum width values are listed in the annotations area, they may not be displayed in the data on lower resolution products. This is because for the 0.27 nm and 0.54 nm resolution products, the maximum velocity and spectrum width values may have been ignored in selecting the first of the 0.13 nm range bins for display.

Implications to the operator

As with Base Reflectivity, AWIPS will display a Base Velocity product with the highest resolution available at each range, if the appropriate ranges are in the database.

4-Bit and 3-Bit Data Levels

Default values for the base velocity data levels:

- 4-Bit (16 data levels) -64 to 64 knots
- 3-Bit (8 data levels) -10 to 10 knots

Data levels are displayed using lower bound thresholds. The numbers beside the color bar in

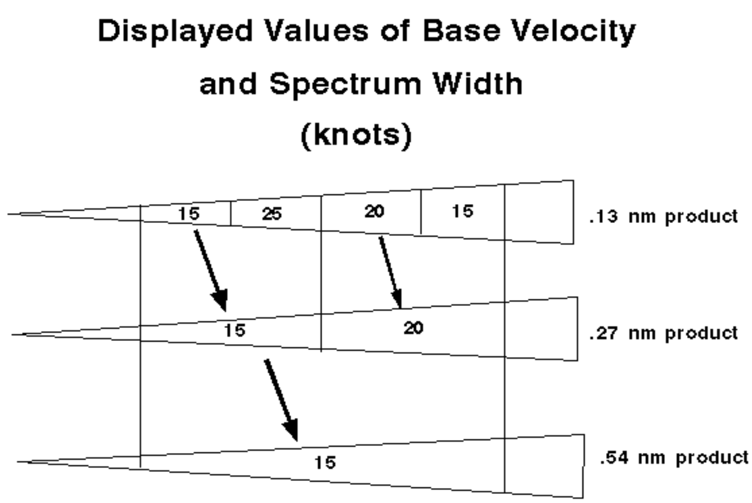


Figure 5-18. Values of velocity and spectrum width retained for display on products of different resolutions.

the status and annotations area of the product are the lowest values in knots for the color. In Figure 5-19, the color beside 35 kts (outbound) actually represents the range from 35 to 49 kts. The color next to - 35 kts (inbound) represents the range from - 35 to - 49 kts.

Changing data levels

Base Velocity data levels can be changed at the RPG HCI. Velocity data levels may be changed to highlight certain significant meteorological situations, such as severe thunderstorm criteria, low level jets, tropical storms, and gap and chinook winds in mountainous regions.

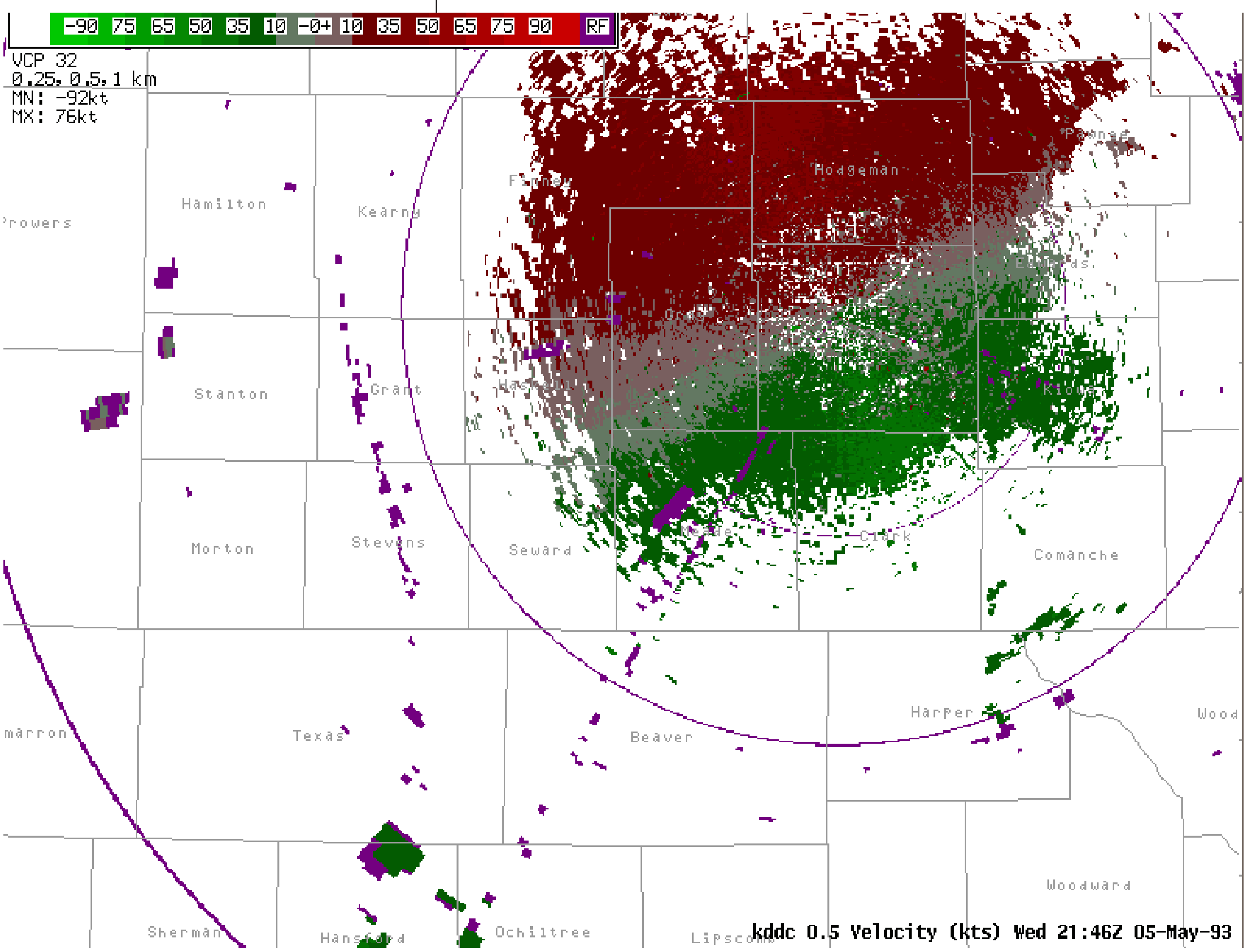


Figure 5-19. Example of displayed resolution differences on a velocity product. All three resolutions 0.13 nm,.27 nm and.54 nm are displayed. The purple range rings mark the resolution changes.

The data level colors may be changed at the AWIPS workstation.

Base Mean Radial Velocity Product Limitations

1. Range folding may obscure data

- Recall from Radar Principles that the range unfolding algorithm compares the ratio of the power return from two targets separated by the maximum unambiguous range (R_{max}) to TOVER. If the ratio exceeds TOVER, the algorithm assigns velocity data to the target with the strongest power return. If the ratio does not exceed TOVER, neither echo is assigned the velocity value, which will then be designated as ambiguous and range folded. In many cases, range folding may obscure needed velocity data.

Operational Solutions

- The radar operator has several options. If the area of interest is obscured by range folding, the RPG HCI operator can adjust the Pulse Repetition Frequency (PRF). This will change the R_{max}, and possibly move the range folding away from the area of interest. The available PRF numbers, 4 through 8, can place R_{max} from 94 to 63 nautical miles.
- Changing VCP to VCP 121 can dramatically reduce range folding. The Multiple PRF Dealiasing Algorithm used in VCP 121 is specifically designed to reduce range folding.
- Range folding may be caused by nearby ground returns that are obscuring data in the second trip. Invoking appropriate clutter suppression at the RPG HCI will reduce the power associated with the ground returns. The area of interest at the second trip may then be the dominant return. If TOVER is exceeded, the 2^{nd} trip return will then be given a usable velocity value.

- Selecting a higher slice may overcome range folding problems, especially if an area of interest in the first trip is being obscured by data in the second trip. By choosing a higher elevation angle, the beam may overshoot the target in the second trip, and display usable velocity data for the area of interest in the first trip.
- The operator may look at another site for a different view of the same storm. For example, the WSR-88D at Indianapolis, IN may be experiencing range folding problems with a storm to their east. The same storm may not be range folded when viewed from the Wilmington, OH WSR-88D.

2. **Improper velocity dealiasing may display erroneous velocity values.**

- The Velocity Dealiasing Algorithm checks each first guess velocity value with neighboring bins. As a last resort, the dealiasing algorithm compares the velocity data to the environmental winds. Failures occur due to lack of surrounding data, or an out of date environmental winds table.

Operational Solutions

- The RPG HCI operator should ensure the Environmental Winds Table represents the atmospheric flow. Keeping the environmental winds table representative will help minimize dealiasing errors and keep errors from propagating through numerous radials.
- Increasing the PRF at the RPG HCI will increase V_{max}, and decrease the amount of aliased velocities. The dealiasing algorithm will have fewer velocities to dealiase, and less chance for error.
- The same problem may not show up on a different elevation slice.

- Changing VCP to VCP 121 not only reduces range folding but can also reduce velocity dealiasing failures.
- The user can request products from another site for a different look at the same storm. An adjacent site may not be having the same dealiasing problem.

Base Mean Radial Velocity Product Applications (Strengths)

1. **Magnitude**
   - Estimate magnitude of radial velocities. Ground relative wind speeds can be estimated for use as input into warnings, statements, and forecasts.
2. **Atmospheric Structure**
   - Determine radial velocity patterns to infer atmospheric structure. Veering or backing winds with height can identify warm air or cold air advection. Low level or mid level jets can be easily identified on the base velocity product.
3. **Storm Structure**
   - Determine radial velocity patterns to infer storm structure. Cyclonic and anticyclonic rotation, storm top divergence, divergence at the surface from microbursts, low level convergence, and the MARC (Mid Altitude Radial Convergence) signature all can be determined from the Base Velocity Product.
4. **Hodographs**
   - Aid in creating, adjusting, or updating hodographs. Hodographs can be created not only for the sounding location or the RDA, but also in the vicinity of a nearby boundary. Wind profiles can be determined to update the hodograph to reflect any changes that may have occurred between soundings.

Base Spectrum Width (SW)

Base Spectrum Width Product Characteristics

Spectrum Width Resolution - 0.13 nm x 1 degree

Spectrum Width products are only available as 3-bit (8 data level) products. As with reflectivity and velocity, AWIPS will display a Spectrum Width product using the best resolution data available in the database (see Fig. 5-20). The three resolutions and corresponding ranges of Base Spectrum Width are 1° beamwidth by:

- 0.25 km / 0.13 nm - Range 32 nm
- 0.50 km / 0.27 nm - Range 62 nm
- 1.0 km / 0.54 nm - Range 124 nm

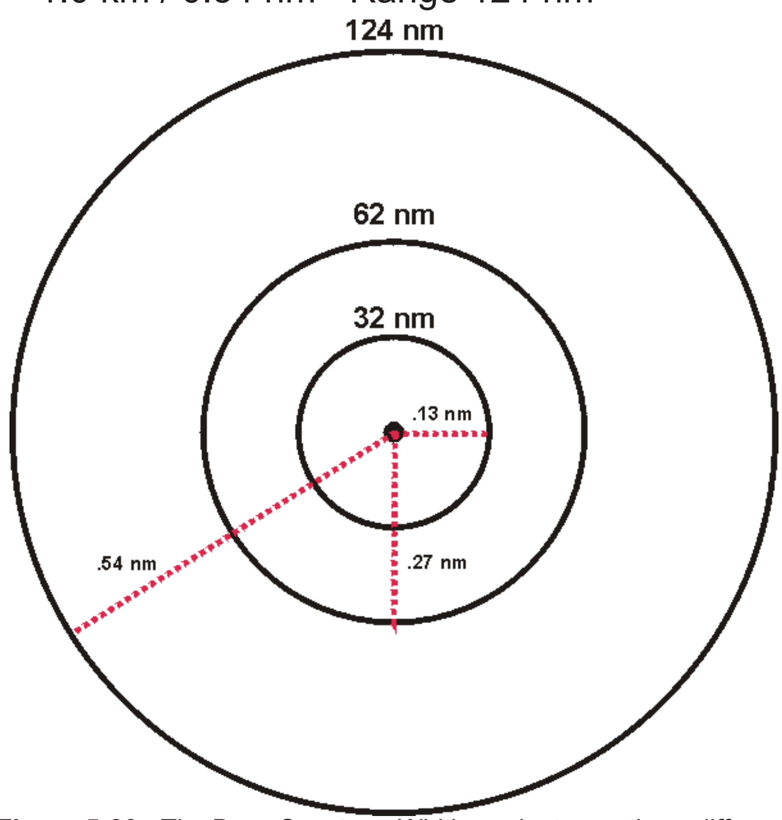


Figure 5-20. The Base Spectrum Width product uses three different resolutions as available.

See Fig. 5-21 on page 42 for a Spectrum Width product

Spectrum Width product legend description:

- RPG ID: kxxx
- ELEVATION ANGLE: x.x in degrees
- PRODUCT NAME: Spectrum Width
- UNITS: kts
- DATE: Day of week, time, and date **in UTC**

Spectrum Width product annotations:

- VCP: VCP 11, 12, 21, 121, 31 or 32
- Product Resolution: 0.13 nm (0.25 km), 0.27 nm (0.5 km), and 0.54 nm (1.0 km)
- Max Value: MX xx kt
  - The location of the maximum spectrum width (0.13 nm resolution) is not displayed and may not be visible in the product.

Spectrum Width **Data Levels - 8 data levels from 0 to 20 knots.**

- Data level values for Spectrum Width do not change with operational mode change. Data levels are displayed using lower bound thresholds.
- Maximum spectrum width is truncated at 19 knots. Spectrum Width values above 19 knots are above the maximum theoretical wideband noise value. Since these values are system related and not data related, they are not displayed.

Typical values

High base spectrum width values result from large velocity differences within a range bin. High velocity differences can result from turbulence, wind shear, differing fall velocities, or from non-meteorological factors.

Stratiform Precipitation

For stratiform precipitation, one would not expect large dispersions in the range bin. Typical spectrum width values for stratiform precipitation are low, in the 0 to 7 kt range.

Turbulent Flow

More variations in the range bin will occur in returns from turbulent areas, such as thunderstorms and outflow boundaries. In those areas, one can expect to see spectrum width values above 8 kts.

Melting Level

Differing fall velocities of rain, wet snow, and snow in the melting level will result in a typical spectrum width of 8 kts.

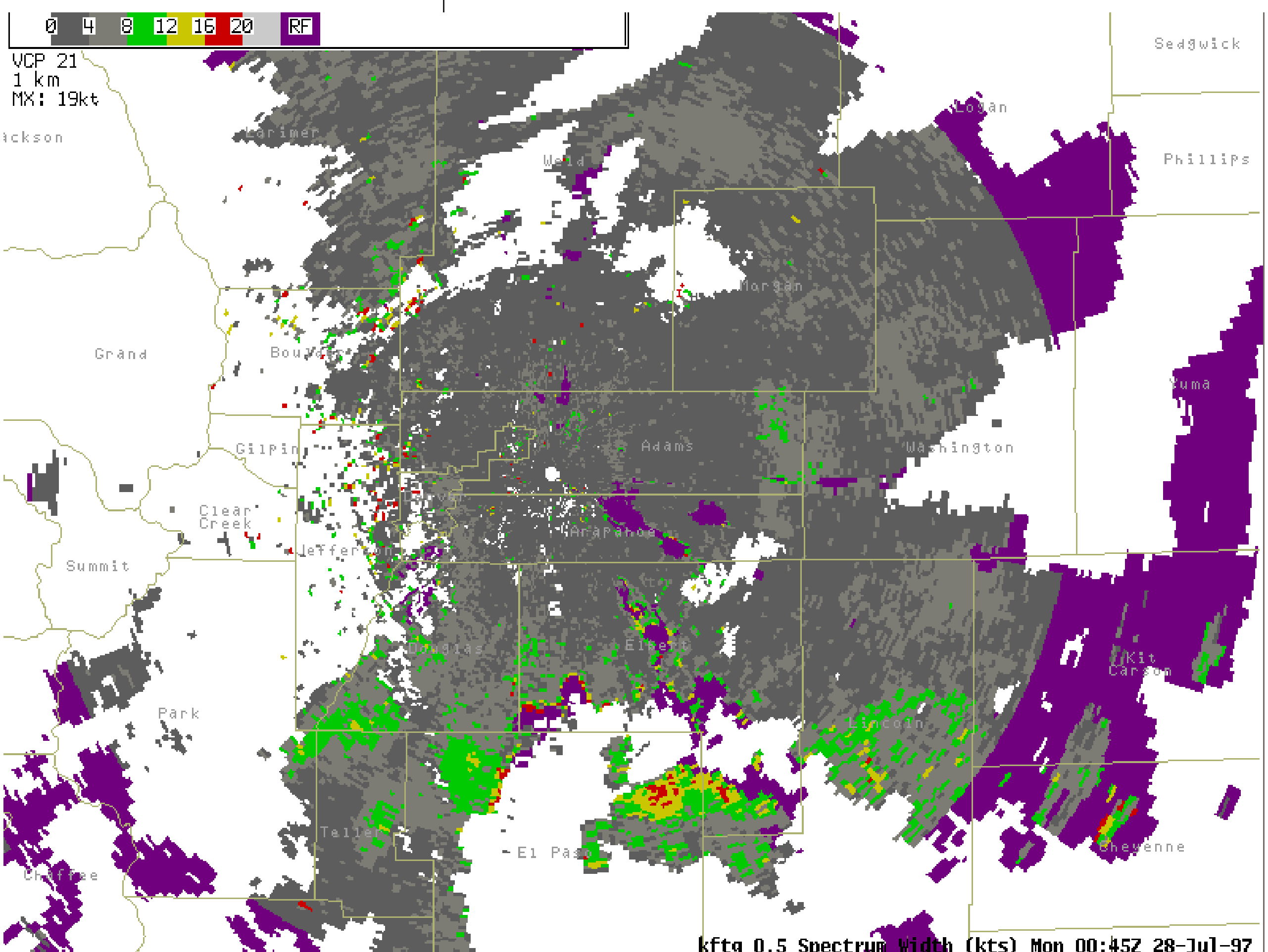


Figure 5-21. Base Spectrum Width.

Base Spectrum Width Product Limitations

1. **Range Folding**
   - As with the Base Velocity Product, range folding may obscure needed spectrum width data.

   Operational Solutions

   - The same solutions for overcoming range folding in base velocity apply to spectrum width as well. Changing the PRF, invoking clutter suppression, viewing a different elevation angle, and requesting products from another site are all options available to the radar operator.

2. **Ground Clutter**
   - Movement of ground clutter may result in high spectrum width values. For example, cars on the road and blowing leaves on trees in the summer can contribute to high velocity variances in the range bin. Turbulent flow around ground targets such as buildings and water towers may also result in high spectrum widths.

   Operational Solution

   - Invoke appropriate clutter suppression at the RPG HCI for the area of concern.

3. **System Noise**
   - Although Base Spectrum Width is truncated at 19 kts to eliminate system noise, spectrum widths from returns near the noise threshold may lead to erratic values. These will be most noticeable as high (12 kt or greater) spectrum widths scattered throughout clear air returns.

   Operational Solutions

   - Try a higher elevation angle or make a request from another site.

4. **Transmission Time**

- Large amount of time is required to send Base Spectrum Width products down the narrowband line.

Operational Solutions

- If Base Spectrum Width is not used often, limit the number of slices on the RPS list. Do one-time requests for additional elevation angles as needed.
- A second solution is to change to a lower resolution. A 0.54 nm Base Spectrum Width typically has less data to display than a 0.13 nm or 0.27 nm product, and will take less time to transmit down the narrowband line.

Base Spectrum Width Product Applications (Strengths)

1. **Evaluate Velocity**
   - Spectrum width can be used to evaluate the reliability of Base Mean Radial Velocity products. Generally speaking, a higher spectrum width value implies more uncertainty in the velocity estimate. ***This may indicate, but does not necessarily mean that the displayed velocity is incorrect***.
   - WSR-88D operators need to look at all the Base Products to determine if the velocity data are accurate. For example, if a Base Velocity Product has strong inbound velocities next to strong outbound velocities, with associated Spectrum Widths > 12 kts, the radar operator should check reflectivity data as well. The velocity signature may be expected after looking at storm structure.
2. **Locate suspected areas of turbulence and shear regions**
   - Shear and turbulence are meteorologically significant. One example of an intense shear region is near the top of a thunderstorm in association with storm top divergence. An 8

data level Base Velocity product can be useful for locating areas where storm top divergence is occurring. Changing the color levels to highlight the highest two velocities can help. Rapid changes in speed and direction seen on the Base Velocity Product can help locate areas of vertical shear that may be hazardous to aircraft.

- Conversely, updraft cores are relatively smooth and display low spectrum widths. Thus, low spectrum width values can indicate regions of updraft in a convective storm.

Interim Summary

Base Reflectivity (Z)

1. Base Reflectivity is the workhorse product of the WSR-88D. It can be used for:
   - observing precipitation intensity, movement, and trends,
   - determining significant storm features,
   - locating and determining the motion of fronts and other boundaries,
   - observing non-meteorological phenomena,
2. When using Base Reflectivity products keep in mind the impacts of radar limitations:
   - Ground Returns
   - Beam Blockage
   - Resolution vs. Range
   - Effects of Earth Curvature
   - Effects of Discrete Elevation Sampling
   - Cone of Silence
   - Chaff

Base Mean Radial Velocity (V)

1. Base Velocity products are extremely valuable product for estimating ground relative wind speed, vertical wind structure, small scale circulations, storm top divergence, microbursts, etc.
2. Interpretation of Base Velocity products is hampered by range folding and improper velocity dealiasing. These problems can be mitigated by changes to PRF, use of VCP 121 (MPDA), selection of different elevations and radars.

Base Spectrum Width (SW)

1. Base Spectrum Width is useful for evaluating the reliability of Base Velocity and locating areas of suspected turbulence and shear or the lack of turbulence and shear.

2. Spectrum width values are impacted by range folding, ground clutter, and system noise.

Lesson 2: Storm Cell Algorithms and Products

Overview

This lesson describes how the Storm Cell Identification and Tracking (SCIT) algorithm identifies, tracks and forecasts the movement of storm cells. Certain attributes of the identified cells are then utilized by the Hail Detection Algorithm (HDA) to calculate probabilities of hail and severe hail, and to estimate maximum hail size. Descriptions and a listing of limitations and strengths are included for the following:

1. **Storm Track Information** (STI - product #58),
2. **Hail Index** (HI - product #59)

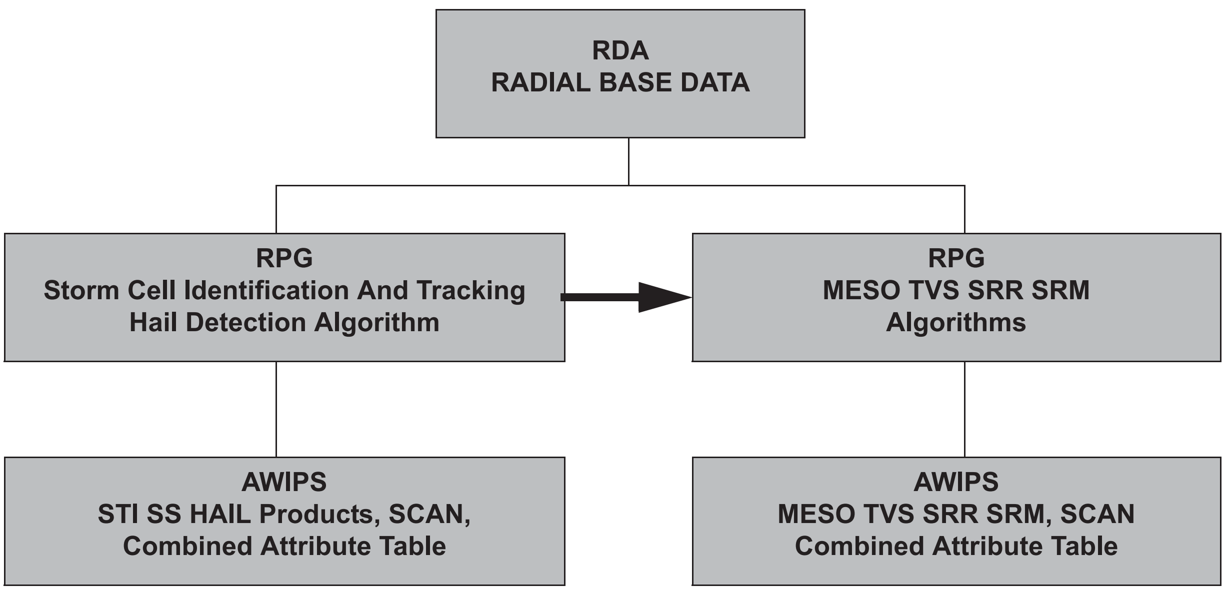


Figure 5-22. Cell attributes from the Storm Cell Identification and Tracking (SCIT) algorithm and the Hail Detection Algorithm (HDA) are displayed directly in some products, and are used indirectly in oth-

Objective

Upon completion of this lesson, you will be able to identify specific characteristics, limitations, and applications (strengths) of the following products:

1. Storm Tracking Information (STI) product, and
2. Hail Index Product (HI).

Storm Cell Identification And Tracking (SCIT)

The objective of the Storm Cell Identification and Tracking (SCIT) algorithm is to identify, track, and forecast the movement of storm cells. The primary graphic product produced by this algorithm is Storm Track Information (STI - Product ID # 58).

Data developed by this algorithm are used extensively as input to several other products (i.e., HI, SS, SRM, SRR, MD, TVS, RCM, CR Combined Attribute Table) and applications such as the System for Convection Analysis and Nowcasting (SCAN)(See Fig. 5-22 on page 49.)

Note: SCAN will **not** be discussed in this section, but will be covered in the DLOC Workshop

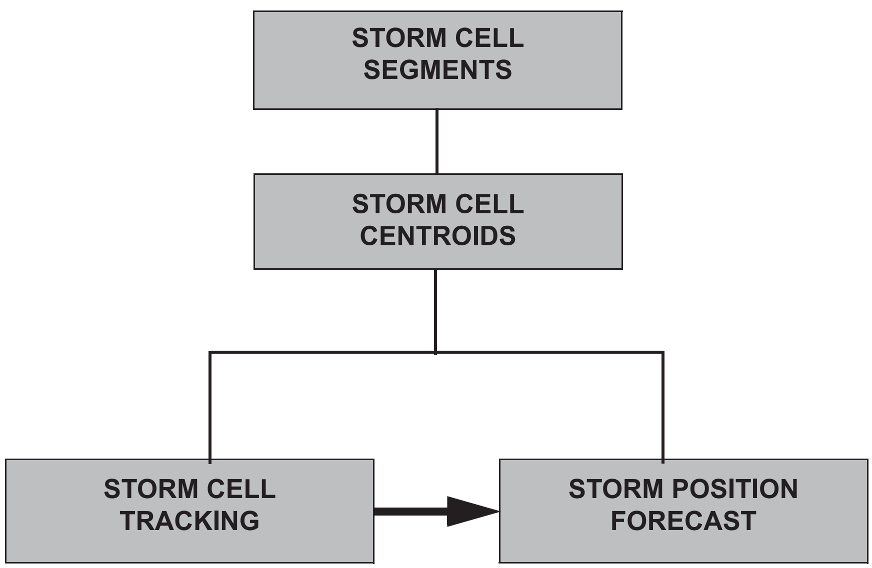


Figure 5-23. The SCIT algorithm consists of four subfunctions.

SCIT Algorithm Overview

The SCIT algorithm consists of four subfunctions: Storm Cell Segments, Storm Cell Centroids, Storm Cell Tracking, and Storm Position Forecast. The **Storm Cell Segments** subfunction identifies the radial sequences of reflectivity (segments), and outputs information on these segments to the **Storm Cell Centroids** subfunction. The **Storm**

Cell Centroids subfunction groups the segments into two-dimensional components, vertically correlates these components into three-dimensional cells, and calculates these cells' attributes. The cells and their attributes are output to Storm Cell Tracking and Storm Position Forecast. **Storm Cell Tracking** monitors the movement of the cells by matching cells found in the current volume scan to the cells from the previous volume scan. **Storm Position Forecast** predicts future centroid locations based on a history of the cell's movement (see figure 5-23 on page 50).

Storm Cell Segments

Definition

Segment - a run of contiguous range bins along a radial with reflectivity values greater than or equal to a specified threshold (see Fig. 5-24).

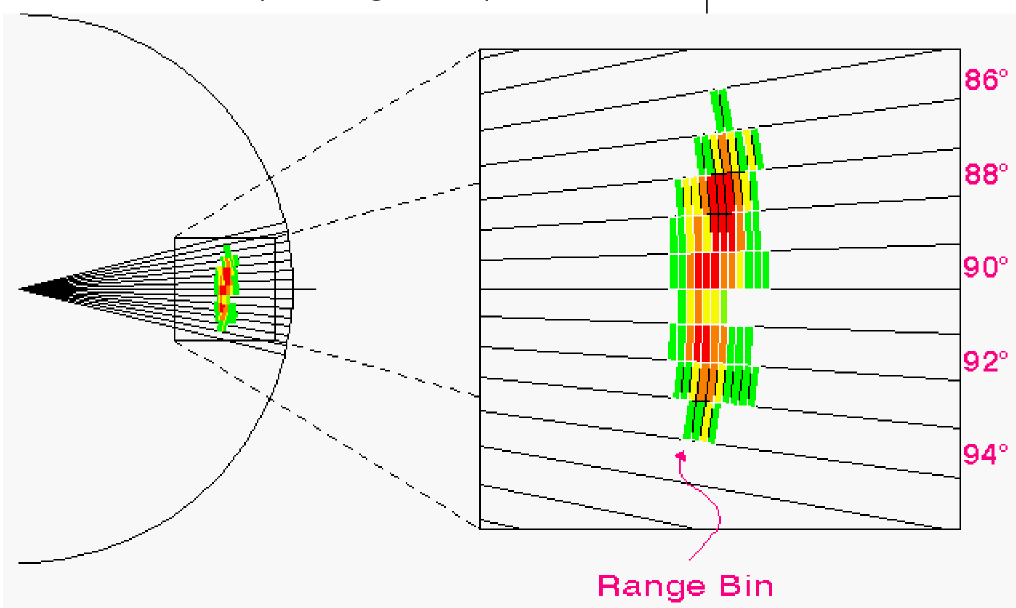


Figure 5-24. Looking closer at the radials, you can see how the reflectivity information is quantified. The basic measurements of reflectivity are made in 1° X.54nm ***range bin***. The function of this algorithm is to combine the individual range bin into storm segments along the radial. Note the segments in

Process

The Storm Cell Segments subfunction searches for segments of up to seven different **minimum reflectivity thresholds** (see figure 5-25 on page

53). The segment must have a length greater than a **minimum segment length**, and may contain a specified **dropout number** of contiguous range bins that are within the **dropout reflectivity difference** below the minimum reflectivity threshold. The default values of the adaptable parameters are:

- Minimum Reflectivity Thresholds = 30, 35, 40, 45, 50, 55, 60, dBZ
- Minimum Segment Length = 1.9 km (1.1 nm or two range bins),
- Dropout Reflectivity Difference = 5 dBZ, and
- Dropout Number = 2.

The *Storm Cell Segments* subfunction searches for segments on each radial as the data arrives at the RPG. First, a search is done for segments using the lowest minimum reflectivity (default is 30 dBZ). All other range bins are discarded from further processing. Then a search is made of the detected (30 dBZ) segments for segments of the next minimum reflectivity threshold (35 dBZ). Then a search of those (35 dBZ) segments is made for segments of the next threshold (40 dBZ), and so on through the seventh threshold (60 dBZ).

A portion of a radial is depicted in the graphic on the next page and annotated with the reflectivity values of each (1° x 0.54 nm) range bin. Given the default values of the adaptable parameters, seven segments would be defined.

As can be seen from the example, numerous segments could be identified along a single radial. To reduce the processing task, the number of segments of a given threshold is limited to 15 (adaptable parameter) per radial. In other words, there is

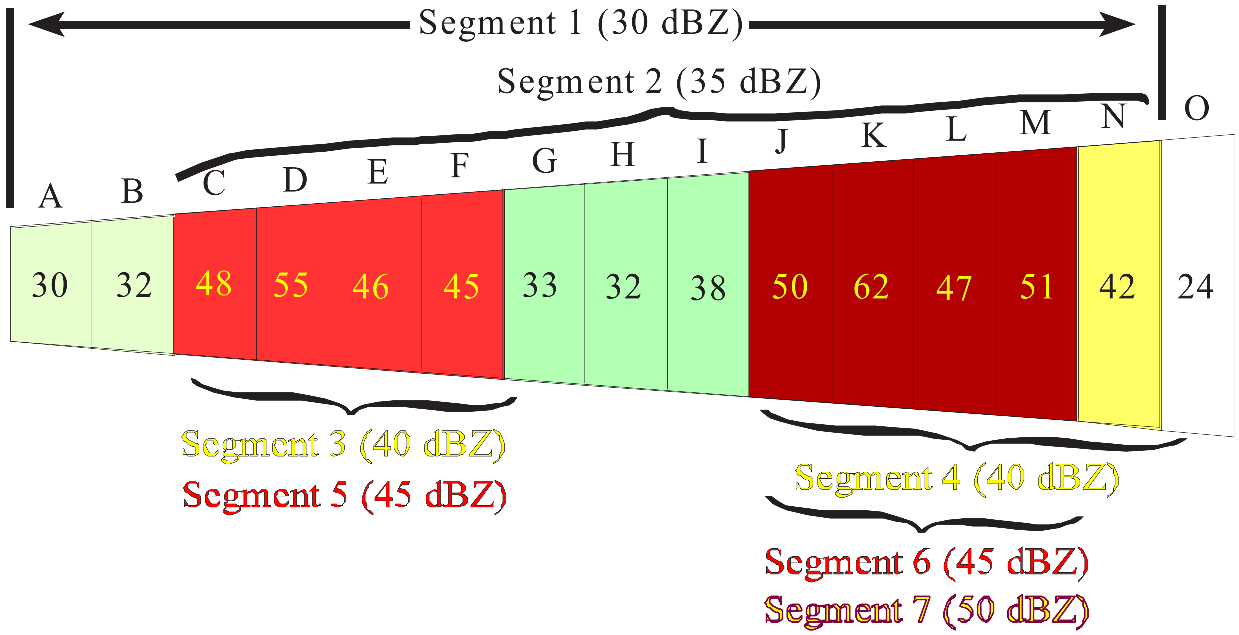


Figure 5-25. In the initial search for a 30 dBZ segment (labeled Segment 1), only the range bin labeled "O" would be eliminated. Segment 2 ("C" through "N") would be selected in the search for 35 dBZ segments (range bins "G" and "H" would remain since up to two contiguous range bins within 5 dBZ of the minimum reflectivity threshold can be contained in the segment). The 40 dBZ segments would include Segment 3 ("C through F") and Segment 4 ("J through N"). Segments 5 and 6 would be defined as 45 dBZ segments, and Segment 7 would be further defined as a 50 dBZ segment. Note that range bin "D" (55 dBZ) and range bin "K" (62 dBZ) would not be considered separate segments since they do not exceed the minimum segment length.

a potential for up to 105 segments on a single radial (7 thresholds X 15 segments per threshold). Investigations have shown that these thresholds will only be exceeded in very active weather situations.

Storm Cell Centroids

Definitions

Component - A two-dimensional area of combined segments on a single elevation slice.

Centroid - A three dimensional location of a cell's center of mass.

Process

At each elevation slice, the Storm Cell Centroids subfunction groups adjacent segments of each reflectivity threshold into two-dimensional components. If components overlap, the component with

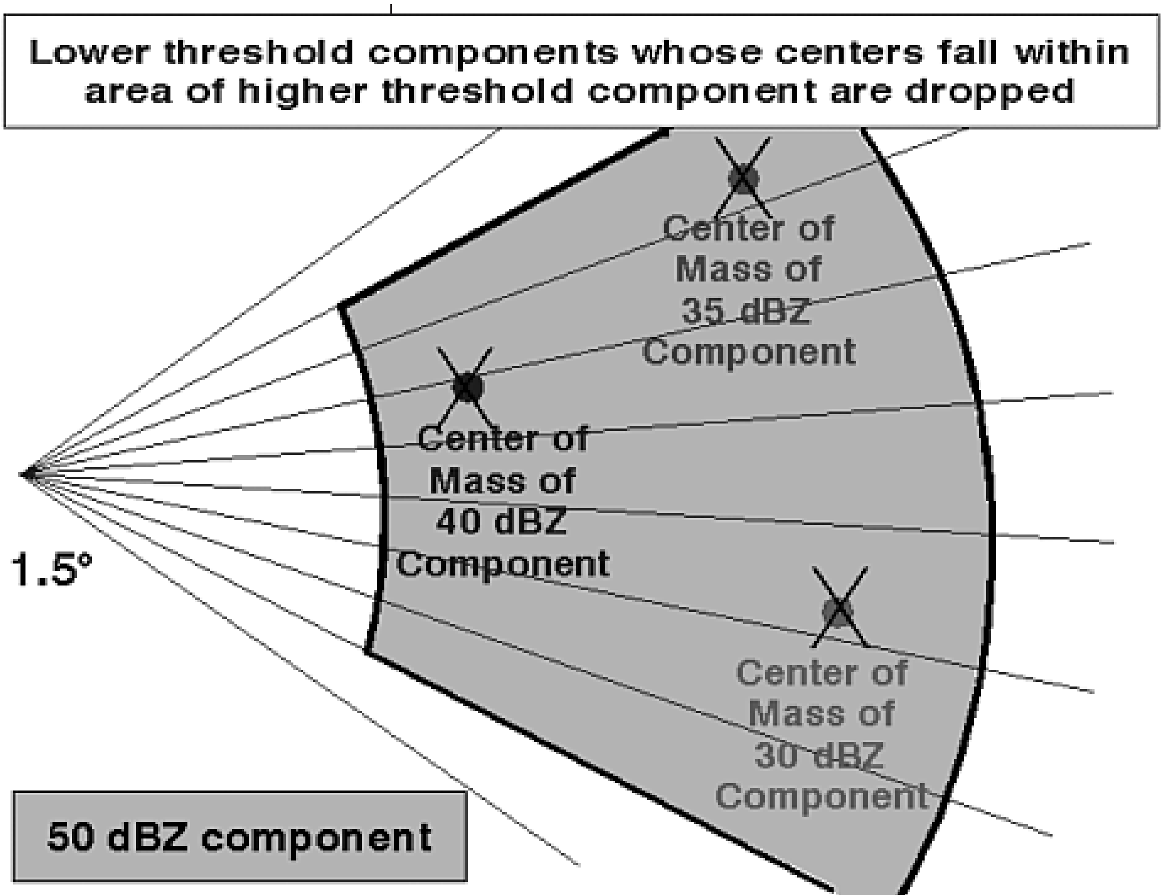


Figure 5-26. Storm Cell Centroid Processing

the higher reflectivity is saved and the other(s) discarded. ***Only the smaller "bull's eyes" of high reflectivity are saved for correlation into three-dimensional cells***. Therefore, cells are defined by their areas of highest reflectivity (see Fig. 5-26).

The components are vertically correlated by comparing the proximity of the centers of every component with those in adjacent elevation scans. Components with the largest masses are compared first. If at least two components are vertically correlated, a cell is created.(see Fig. 5-27)

Storm Cell Centroids Output

For each identified cell the following attributes are calculated:

- centroid (in polar coordinates),

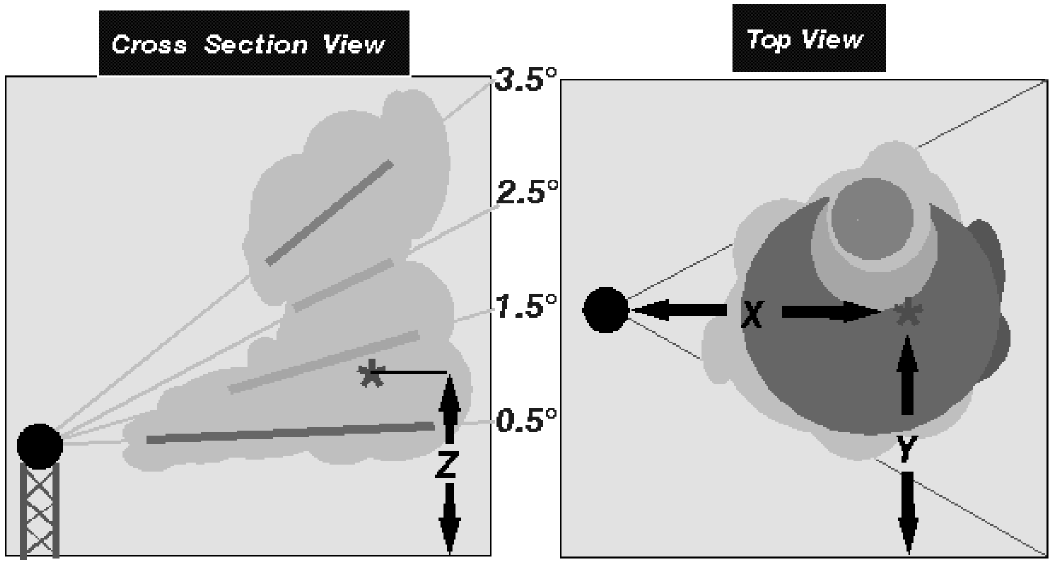


Figure 5-27. Centroid Locations

- height of the centroid (ARL - Above Radar Level),
- maximum (3-bin averaged) reflectivity,
- height of the maximum reflectivity (beam centerpoint height - ARL),
- cell base and top (ARL),
- number of components, and
- Cell-based Vertically Integrated Liquid (VIL).

Cell-based VIL

A calculation of VIL is made for each cell identified by Storm Cell Centroids by vertically integrating maximum reflectivity values of a cell's correlated components. This is a **different** calculation than the gridded VIL product (VIL - Product ID #57). As can be shown on the following example (See Fig. 5-28 on page 56.), a fast-moving or highly tilted storm will usually have a higher Cell-based VIL than Grid-based VIL.

Up to **100 cells** can be identified by Storm Cell Centroids. The cells are ranked by Cell-based VIL. Cell-based VIL is displayed in SCAN, the Storm

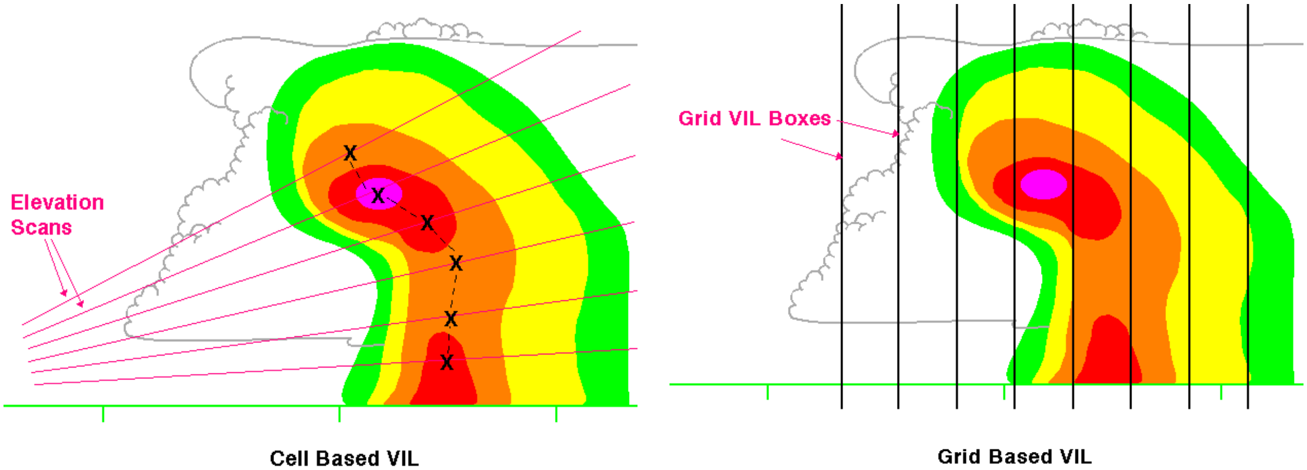


Figure 5-28. Cell-based vs. Grid-based VIL.

Structure Alphanumeric Product, and the Composite Reflectivity Combined Attributes Table.

Storm Cell Tracking

Process

Storm Cell Tracking monitors the movement of storm cells by matching cells found in the current volume scan to the cells from the previous volume scan. Starting with the cell with the highest Cell-based VIL, a comparison is done of its centroid location with the projected (based on past movement) centroids from the previous volume scan. The closest projected centroid within a threshold distance (speed limitation) is considered the same cell (See Fig. 5-29 on page 57.).

If a correlation is made, the cell is given the same ID as in the previous volume scan. If no correlation is made, the cell is given a new ID. The ID assigned to a Cell consists of a letter-number combination (A0, B0, C0... Z0, A1, B1... Z1, A2, B2... Z9). This adds some value to the ID, such as cell R7 has been identified longer than cell H8 (**the number has precedence over the letter in this scheme**). The list of IDs will reset to begin with A0

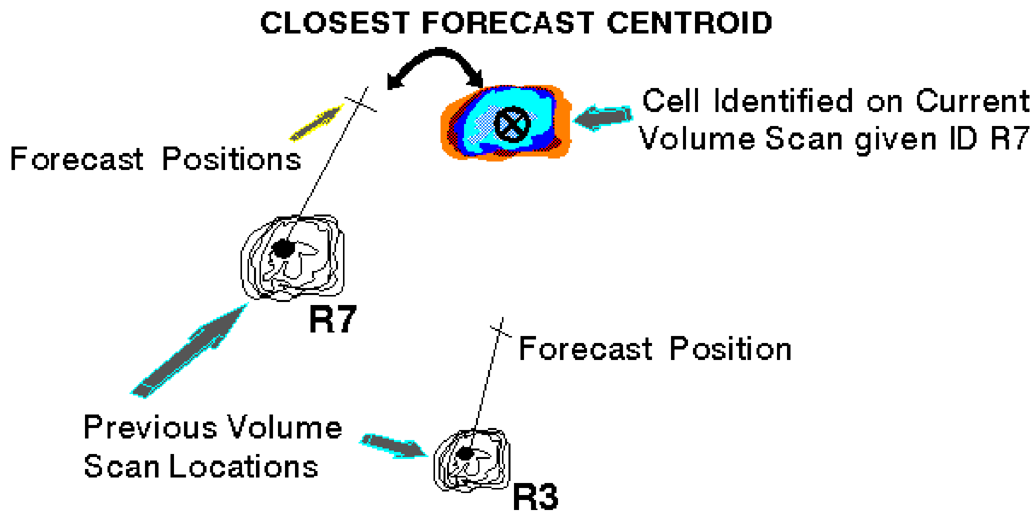


Figure 5-29. Storm Tracking Process. Centroid location is compared with forecast location of centroids from the previous volume scan.

when the RPG is rebooted, or when a threshold time interval has lapsed without cells.

Storm Position Forecast

Process

Storm Position Forecast predicts the future centroid locations of cells based on a history of the cell's movement. The first time a cell is detected it is labeled a new cell, and the forecast movement used by the algorithm for processing purposes is either:

a) the average movement of all identified cells, or

b) if no other cells are identified, the default speed and direction as set at the RPG HCI.

Subsequently, each time the cell is detected, a prediction is made using a linear least squares extrapolation of the cell's previous movement. A comparison of the current centroid location is made to the previous forecast position, with the duration of the forecast (0, 15, 30, 45, or 60 minutes) dependent on the magnitude of this departure. In other words, the larger the errors in past volume scans forecasts, the shorter (in time) the forecast.

Storm Track Information Graphic Product

Product Description

Data developed by the SCIT algorithm is directly input to the Storm Track Information Product (STI - Product ID #58). The STI product can display up to 100 cells identified by the SCIT algorithm on a single product. It is also possible to display the actual past positions of the centroid on up to 13 (default 10) previous volume scans. Cells with a movement of less than a minimum speed (default 5 kts) are circled to indicate little movement, and past positions and forecast tracks are not displayed. The following symbols are displayed on the product:

⊗ centroid location,

• past position (volume scan increments with a line between each symbol), and

+ forecast position (15 minute increments with a straight line connecting all forecast positions),

Ⓕ stationary (<5 kts).

STI Product Characteristics

See Figure 5-30 for an example of the STI product.

STI product legend description:

- RPG ID: kxxx

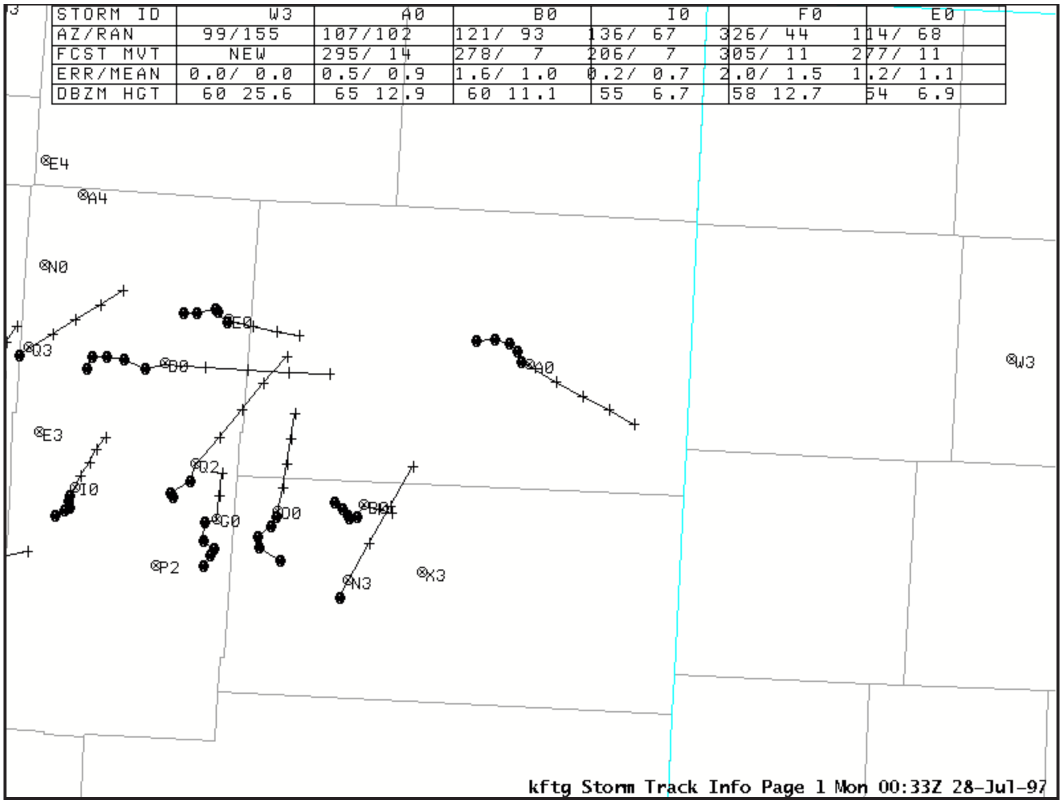


Figure 5-30. Storm Track Information (STI) Product.

- PRODUCT NAME: Storm Track Info
- PAGE #: This is the page number of the attribute table.
- DATE: Day of week, time, and date in UTC

STI product annotations:

- STI Attribute Table

Additional STI Product Characteristics

- RANGE: 248 nm (Effective Range 186 nm)

STI Attributes Table

The STI Attribute Table appears at the top of the STI product, and contains information on all identified cells (see Fig. 5-31). The STI Attribute Table lists the cells in order of **Cell-based VIL** from left to right from page 1 to the last page. On the first volume scan a cell is identified, the word “NEW” is placed on the line for forecast movement.

The fourth line of the STI Attribute Table lists the error (ERR) of the previous forecast track location to the current centroid position (in nm). The mean error (MEAN) is the average error over the cells lifetime (also in nm). The larger the mean error (MEAN), the fewer the forecast tracks (15, 30, 45, 60 min.) plotted on the STI graphic.

If 100 cells were identified, with only six cells per page, there would be 17 pages of attributes, although only 6 pages are currently viewable in AWIPS.

STORM/ID	W3	A0	B0	I0	F0	E0
AZ/RAN	99/155	107/102	121/ 93	136/ 67	326/ 44	114/ 68
FCST/MVT	NEW	295/ 14	278/ 7	206/ 7	305/ 11	277/ 11
ERR/MEAN	0.0/ 0.0	0.5/ 0.9	1.6/ 1.0	0.2/ 0.7	2.0/ 1.5	1.2/ 1.1
DBZM HGT	60 25.6	65 12.9	60 11.1	55 6.7	58 12.7	54 6.9

Figure 5-31. STI Attribute Table which appears at the top of the STI product.

Storm Track Information Alphanumeric Product

An STI Alphanumeric Product is received and stored in a text file along with every STI Graphic Product. The name of the text file is in the form: ***WSRSTIxxx***, where xxx is the radar ID. The STI Alphanumeric Product is displayable at the AWIPS text workstation, and contains information on the position and forecast of identified cells. The average speed and direction of all identified cells are shown near the top of the product. Cells are listed in order of Cell-based VIL from left to right. The azimuth and range of the current cell centroids along with the movement and forecast positions at 15, 30, 45, 60 minutes are listed.

STI Limitations

1. ***Errors may occur in the identification of cells and the calculation of cell attributes when cells are in close proximity.*** Recall from the previous discussion of Storm Cell

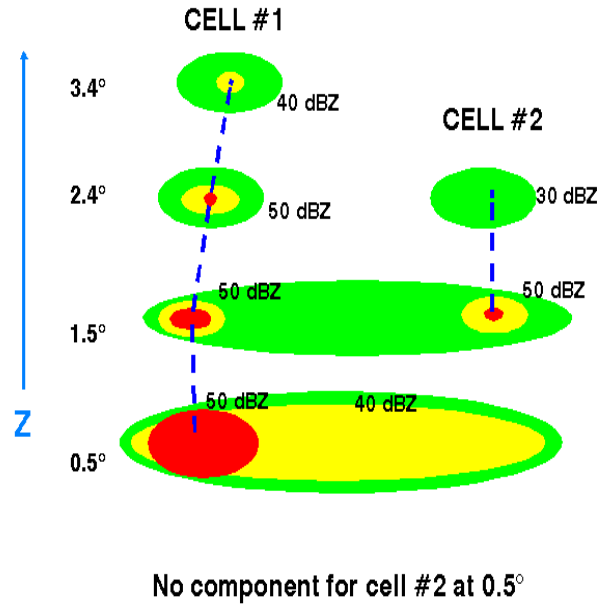


Figure 5-32. Storm Cell Centroids that storm cells are defined by areas of highest reflectivity.

Centroids that storm cells are defined by areas of highest reflectivity.

- In Figure 5-32, a particularly high area of reflectivity (50 dBZ) occurred in Cell #1 at 0.5°, and only this area was saved as a component. Cell #2 has been identified with a Cell Base defined at the 1.5° slice even though a 40 dBZ echo exists at the 0.5° slice.
- This type of problem will also affect other calculations such as Cell Top, Maximum Reflectivity Height, and Cell-based VIL. The operator should be skeptical of cell attributes anytime cells are in close proximity to each other.
- Cell attributes of supercells may also be inconsistent. The number of identified cells in a large supercell storm may vary from volume scan to volume scan. An example of this problem is seen on Figure 5-33, where cell-based VIL is compared to gridded VIL for a large supercell storm.

2. ***Large errors may occur in the attributes of cells close to the RDA, especially in VCP 21***

and VCP 121. Recall that there are large gaps between elevation angles at higher slices in VCP 21 and VCP 121. Calculations of Cell-based VIL, Cell Base, Cell Top, Height of Maximum Reflectivity, etc. can all be adversely affected by what the radar is **not** sampling in these gaps.

3. ***Unrepresentative movements are possible due to propagational effects.*** Due to development or dissipation, the high reflectivity cores change location within an identified cell from one volume scan to the next, resulting in false representation of the movement of the cell.

4. ***Forecast positions of curving cells are displayed as a straight line.*** Since position forecasts are always in a straight line, the past tracks of a cell should be taken into account when using the position forecast of a curving cell.

STI Applications (Strengths)

1. ***The product works best with well-defined widely separated cells***.

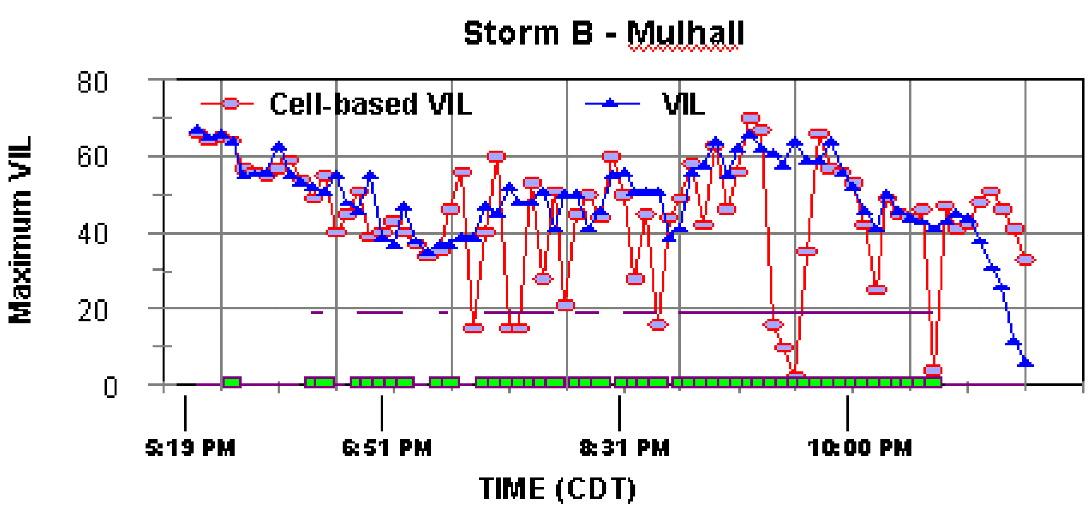


Figure 5-33. Comparison of cell-based VIL and gridded VIL for the "Mulhall" Storm that produced a long track tornado through the town of Mulhall, Oklahoma on May 3, 1999.

2. ***A large number of past tracks, and/or four forecast positions signifies a more reliable cell movement.*** Uneven spacing between past tracks, fewer than four forecast positions, and/or reidentification of cells indicate less reliable forecast positions.
3. ***The STI product is useful as an overlay on volume products, but not limited to volume products***.
4. ***Cell motion is used in Storm Relative Velocity products (SRM)*** covered in Lesson 4.
5. ***Cell attributes are critical inputs to the Hail Index product and SCAN.***

Radar Graphics Control

During active weather, the STI product could become extremely cluttered. Graphic controls are available at the AWIPS Workstations to allow the operator to reduce the clutter on the STI product. (See Fig. 5-34.)

The number of identified cells to be displayed (up to 100), and whether or not to display the past positions and/or forecast positions is independently selectable at each AWIPS Workstation. If 30 cells are identified by the SCIT algorithm, and an operator selects only 10 to be displayed, only the top 10 ranked by Cell-based VIL would be displayed on the STI graphic product. Information on all 30 cells are available on pages 1 through 5 of the STI Attribute Table and also on the paired STI alphanumeric product. All other AWIPS Workstations will not be effected by this setting.

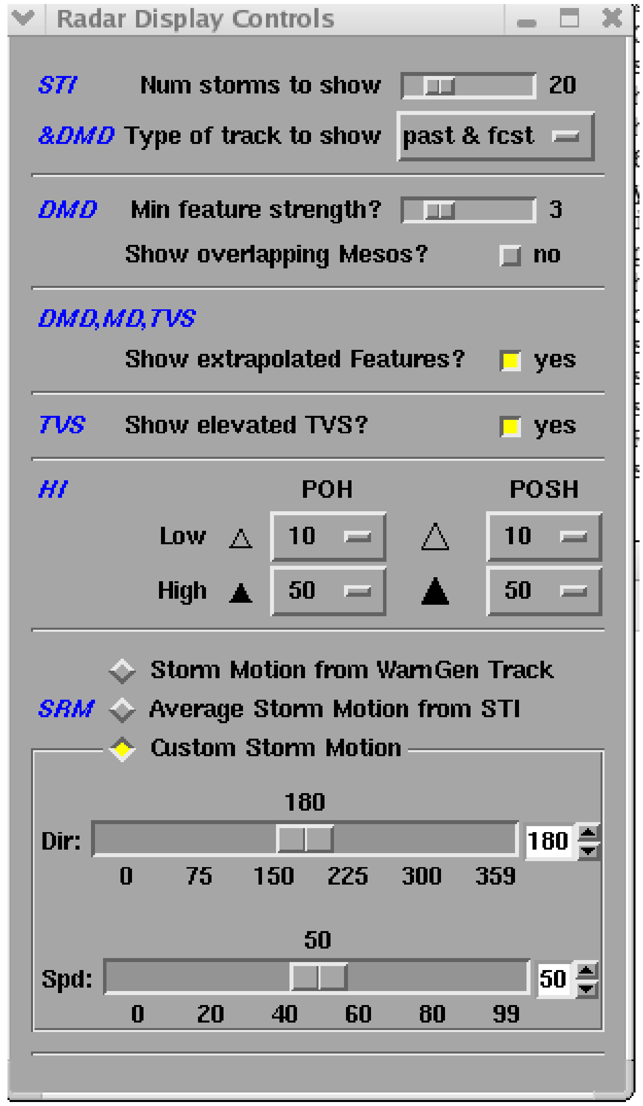


Figure 5-34. AWIPS Radar Display Controls for STI, HI, DMD, MD, TVS and 8-bit SRM products.

Hail Detection Algorithm (HDA)

Introduction

The Hail Detection Algorithm (HDA) has been designed to look for high reflectivities above the freezing level. Input of the 0°C and -20°C altitudes at the RPG HCI from a recent representative sounding can greatly improve algorithm output. The algorithm is designed to work independent of cell type, tilt, and overhang. The primary product produced by the algorithm is Hail Index (HI - Product ID #59) which can be useful in identifying cells that have the potential to produce hail.

The Hail Index product displays the following HDA estimates:

Probability Of Hail (POH) - identified as hail of any size, displayed in increments of 10%,

Probability Of Severe Hail (POSH) - identified as hail that is $\geq$ 3/4 inch, displayed in increments of 10%, and

Maximum Expected Hail Size (MEHS) - the estimate of the largest hail size identified anywhere in the cell, computed in increments of 1/4 inch.

If the cell is beyond the hail processing range of 124 nm, then the hail estimates are labeled as UNKNOWN in the Attribute Table.

Process

The Hail Detection Algorithm searches for high values of reflectivity above the freezing level (See Fig. 5-35 on page 66.). The reflectivities used are the maximum reflectivities of cell components above the freezing level. For the calculation of the POH, the location of the highest reflectivity of at least 45 dBZ above the freezing level is found. The greater the height above the freezing level, the greater the POH. In the calculation of POSH and MEHS, reflectivities greater than 40 dBZ which exist above the freezing level are used. In addition, a weighting factor is used, such that the greater the reflectivity above 40 dBZ, and the higher the altitude at which this reflectivity exists, the greater the weighting factor used. Reflectivities greater than 50 dBZ, and higher than the altitude of the -20°C isotherm, carry the most weight. **This illustrates the need for users to update the altitude of the 0°C and -20°C levels regularly**, especially when significant change to the atmosphere is experienced near the radar coverage area.

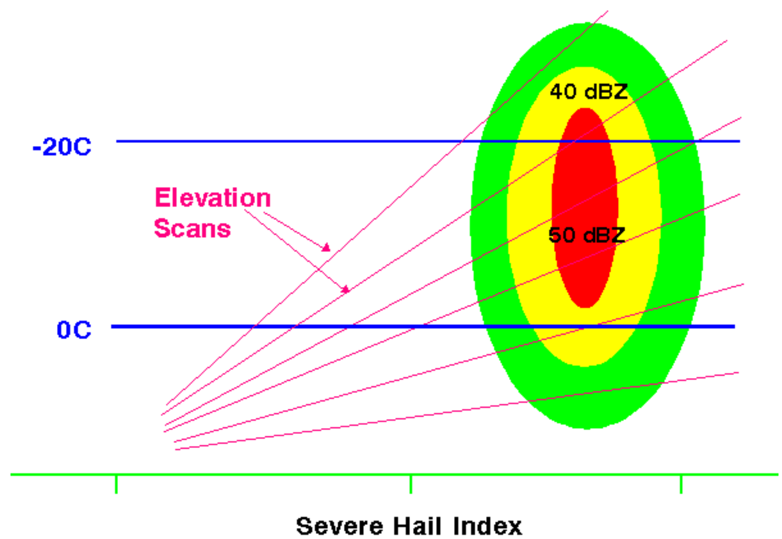
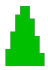


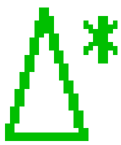
Figure 5-35. Hail Algorithm Process.

Hail Index Product

The Hail Index (HI - Product ID #59) graphic product uses symbols to depict the probability of hail. The POH will be represented with a small open or solid green triangle. For the triangle to appear the POH must exceed a **"Minimum Display Threshold"**(10% default). Whether the triangle is open or solid green depends on a **"Fill-in Threshold"** (50% default). The POSH is represented by a larger green triangle, again with the solid green triangle representing a "fill-in" threshold. The MEHS will be displayed in the center of the POSH symbol rounded to the nearest inch from 1 to 4. If a cell has hail identified that is less than 3/4 inch, then an asterisk (*) will be placed in the center of the POSH symbol (See Fig. 5-36 on page 5-67.).

 Minimum POH Display Threshold ≤ POH < Fill-in Threshold

 POH ≥ Fill-in Threshold **&** POSH < Min. POSH Threshold

 Minimum Display Threshold ≤ POSH < Fill-in Threshold

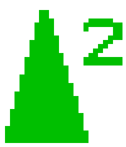
 POSH ≥ Fill-in Threshold

Figure 5-36. Hail Symbols

Hail Index Attributes Table

The Hail Index Attributes Table will be available at the top of the product which lists the Cell ID, Azimuth and Range, POSH or POH, the MEHS (to the nearest 1/4 inch), and the last line in the table identifies the altitudes of the temperatures and the date/time at which the information was last updated, (1/1/96 12Z is displayed if data has not been entered). Each page of the table can contain up to 6 cells. Cells are ordered first by POSH and then by POH. In addition, the parameters of POSH, POH, and MEHS will be displayed in the Composite Reflectivity Combined Attribute Table and the Hail Index alphanumeric product.*Icon Graphic Controls*

Graphic controls are available at the AWIPS Workstations to allow the operator to adjust the Minimum and Fill-In Thresholds for the Hail Index

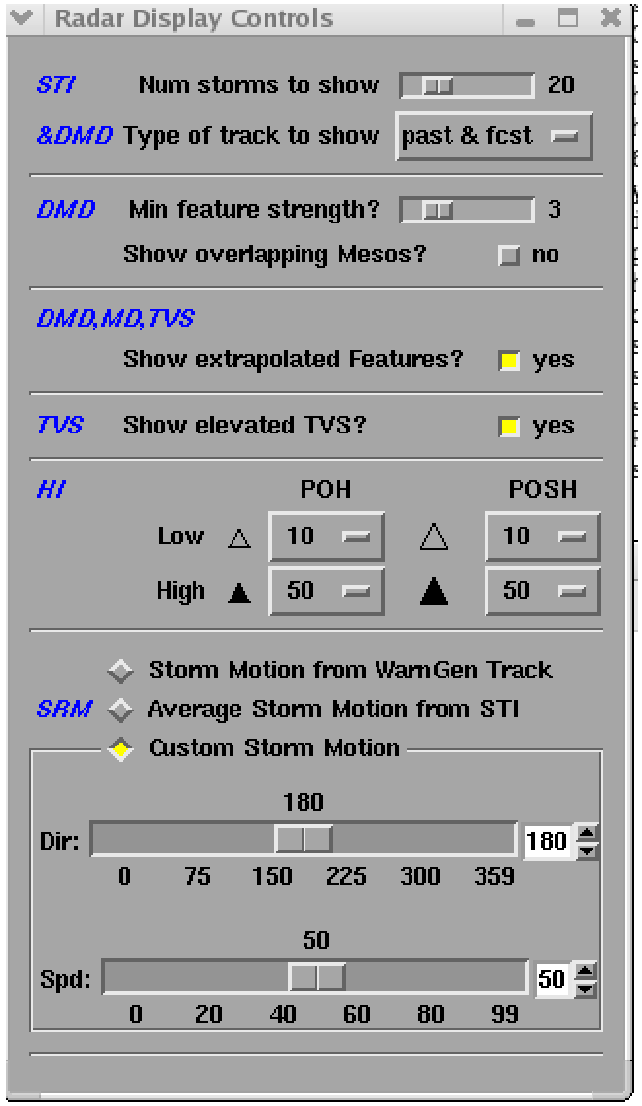


Figure 5-37. AWIPS Radar Display Controls for STI, HI, TVS, MRU, and 8-bit SRM products.

Icons. Changes made here will not effect other AWIPS workstations (see Fig. 5-37).

Hail Temperature Height Selection

The 0°C and -20°C heights used by the Hail Algorithm can be entered at the RPG HCI under the Environmental Data, to allow (under URC authority) the operator to input the most recent altitudes (See Fig. 5-38 on page 5-69.).

These values should be obtained from representative sounding information. If no recent nearby sounding is available, a forecast sounding or inter-

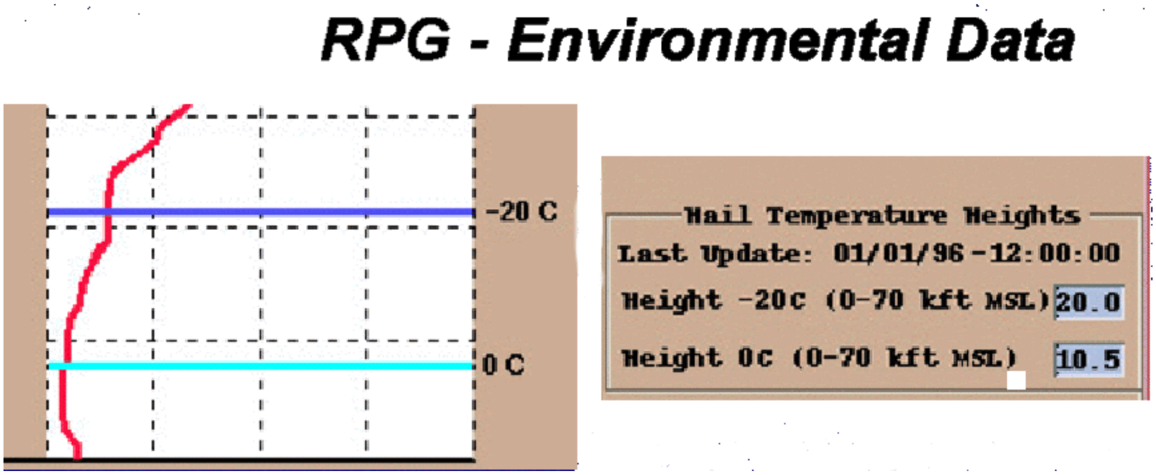


Figure 5-38. Hail Temperatures edit screens at the RPG HCI.

polation from surrounding soundings is recommended. **This should be done twice daily or as meteorological conditions warrant for the algorithm to provide accurate hail estimates.**

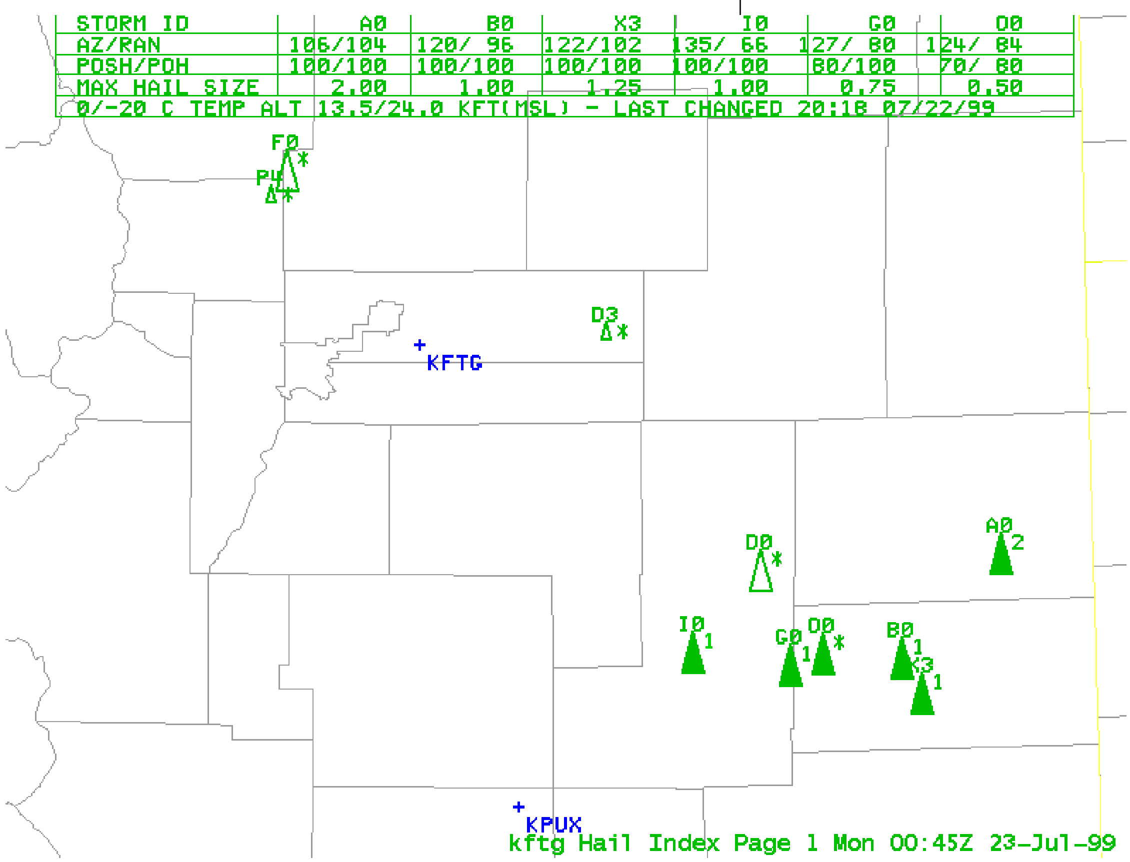


Figure 5-39. Hail Index (HI) Product

HI Limitations

1. **The Hail Detection Algorithm needs as input, accurate and timely measurements of the MSL altitudes for the 0°C and -20°C levels.** Failure to update this information will degrade the algorithm's performance.
2. **Values of POH, POSH, and MEHS will fluctuate at close ranges, especially in VCPs 21 and 121**, due to gaps in coverage at higher elevation slices.
3. **The values for POH, POSH, and MEHS may fluctuate at long ranges from the radar,** due to the limited number of slices through the cell.
4. The maximum hail processing range is 124 nm. **For cells beyond 124 nm, hail will be identified as UNKNOWN**.
5. **POSH and MEHS tend to overestimate the chances and size of hail in weak wind and tropical environments and mountainous locations**. The accuracy of the hail estimates partially depends upon the accuracy of cell (component) information.
   - MEHS is an estimation of the largest hail in the cell, and often times, most of the hail from a cell is smaller.
   - The operator has to keep in mind that the MEHS should only be used as a guide. Storm spotters and other operational means should be integrated into the warning decision.

HI Application (Strength)

1. **The Hail Detection Algorithm has shown a very high probability of detection in cells that contain severe hail,** especially greater than one inch diameter hail. A POSH of 50% or greater has shown skill as a warning threshold.

Interim Summary

Storm Track Information (STI) Product

1. Errors occur in cell identification and tracking when cells are in close proximity.
2. Cell identification and tracking work best when storms are separated and little development or dissipation is occurring.
3. A large number of past tracks and/or four forecast positions are indications of reliable tracking.
4. Cell attributes are unreliable in VCP 21 and 121 within 60 nm of the RDA.

Hail Index Product

1. Hail Index (HI) displays three values: Probability of Severe Hail (POSH), Probability of Hail (POH), and Maximum Expected Hail Size (MEHS) for identified cells.
2. Hail attributes are calculated by comparing SCIT defined component maximum reflectivity heights to operator input heights of the 0 and minus 20 degree heights.

Lesson 3: Reflectivity Based Products

Objectives

Upon completion of this lesson, you will be able to identify specific characteristics, limitations, and applications (strengths) of the following products:

1. Vertically Integrated Liquid (VIL)
2. Digital (or High Resolution) VIL (DVL)
3. Reflectivity Cross Section (RCS)
4. Composite Reflectivity (CZ)
5. Layer Composite Reflectivity Maximum (LRM)
6. User Selectable Layer Reflectivity (ULR)
7. Enhanced Echo Tops (EET)

Vertically Integrated Liquid (VIL)

VIL values represent reflectivity data converted into equivalent liquid water values. What you are really viewing is integrated reflectivity, <u>not</u> a storm's precipitable water content, as was the original intent.

Process

The VIL equation is:

$$M = 3.44 \times 10^{-3} Z^{4/7}$$

where M = liquid water content (g m-3)

Z = radar reflectivity (mm6 m-3)

The values are derived for each 2.2 x 2.2 nm grid box; then vertically integrated. VIL values are output in units of mass per area (kg m^{-2}).

The algorithm ***assumes reflectivity returns are from liquid water,*** only using reflectivities greater than 18 dBZ.

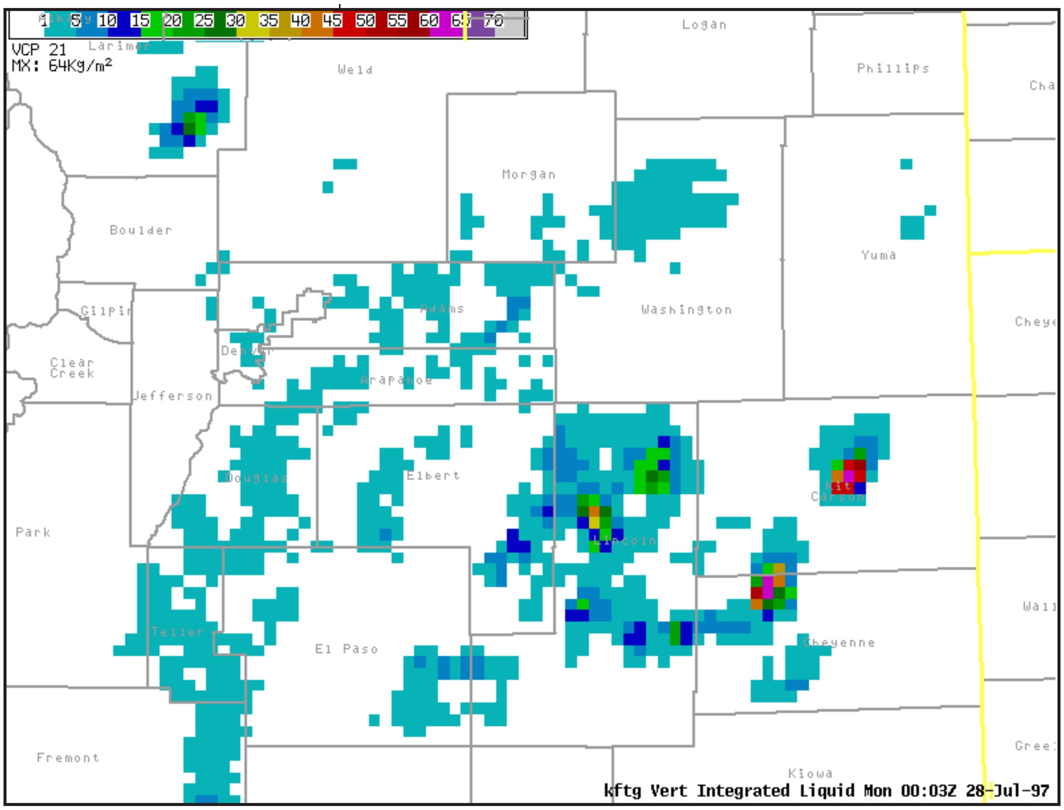


Figure 5-40. Vertically Integrated Liquid (VIL) product

Reflectivity returns from hail are non-linear & would result in unrealistically high values, so all reflectivities greater than 56 dBZ are truncated to 56 dBZ.

VIL Product Characteristics

See Figure 5-40 for an example of the VIL product.

VIL product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Vert Integrated Liquid
- DATE: Day of week, time, and date in UTC

VIL product annotations

- VCP: 11, 12, 21, 121, 31 or 32
- MX: This is the maximum value in kg/m^2. The location of this value is unknown.

Additional VIL product characteristics

- RANGE: 124 nm
- RESOLUTION: 2.2 x 2.2 nm
- DATA LEVELS: Data level values range from 1 kg/m^2 to 70 kg/m^2.

VIL Limitations

1. VIL values are biased by drop size.

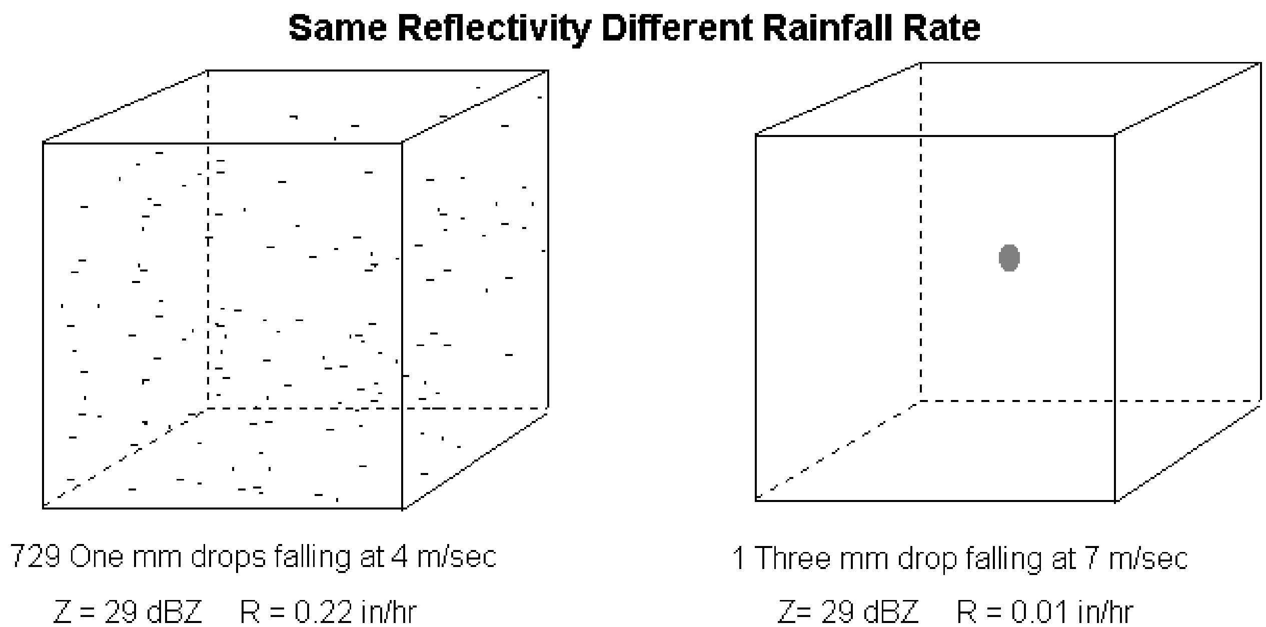


Figure 5-41. Effect of drop size on target reflectivity

2. Grid VIL values will differ from Cell-Based VIL values.

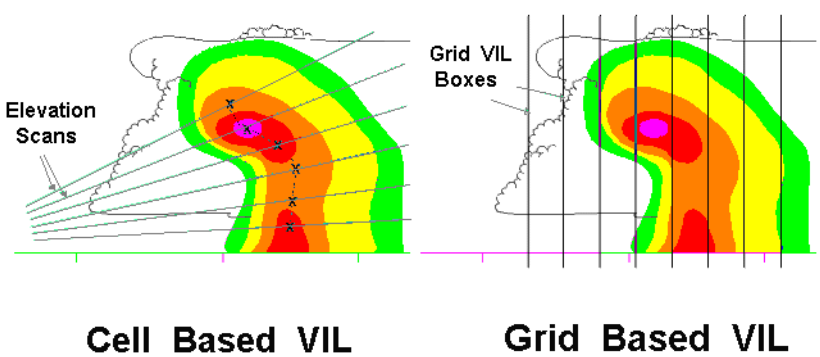


Figure 5-42. Cell-based vs. Grid-based VIL.

3. **Values for warnings may change daily and across the *warning area.*** Values are air mass dependent.

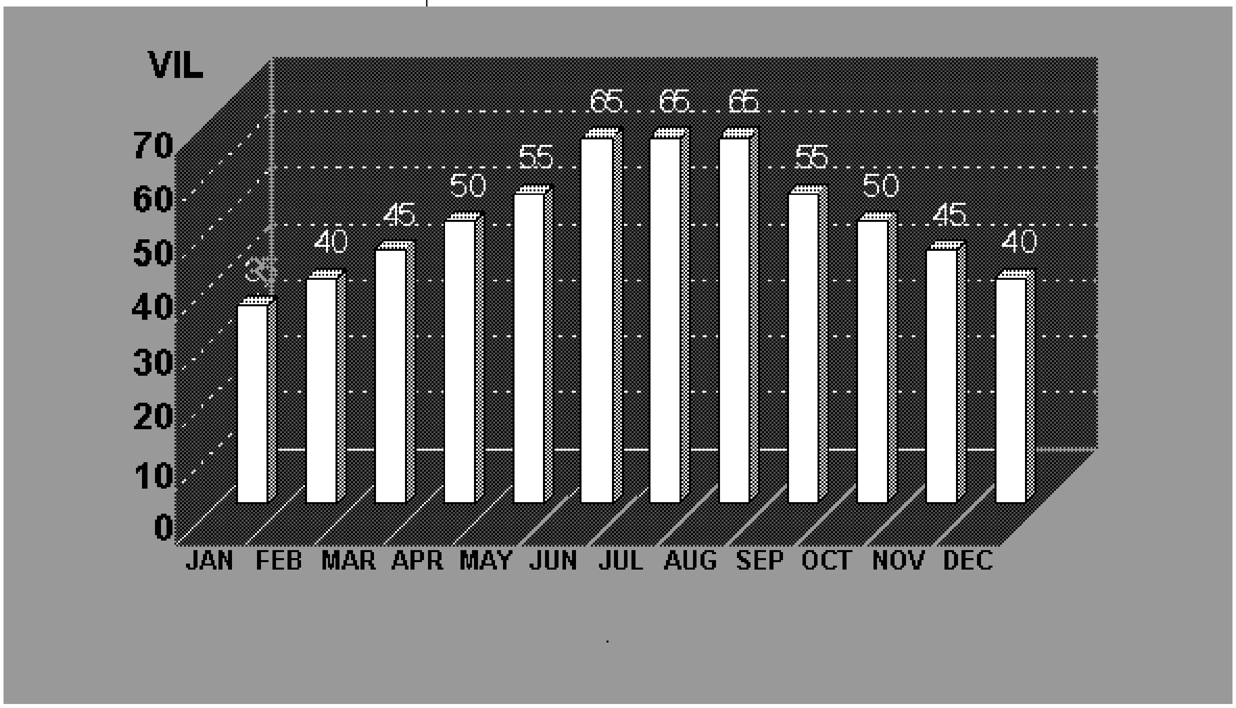


Figure 5-43. Estimated VIL values needed for large hail in Oklahoma.

4. **Values within 20 nm of radar are underestimated.** This is due to the cone of silence.
5. **VIL values for a strongly tilted or a fast moving storm will be *lower* than if the storm was vertical or moving slower.** The upper portion of the storm may extend into another grid box.
6. **May be contaminated by non-precipitation echoes.**
7. **More VIL fluctuation with VCPs 21 and 121 than VCPs 11 or 12.** There are fewer gaps in VCPs 11 and 12. This is mainly within 60 nm of the radar. This study is of observed VIL values (see Fig. 5-44).
8. **Values at distant ranges ($\geq$ 110 nm) are *unreliable.*** The reflectivity value at 0.5° is integrated down to the radar level. At distant

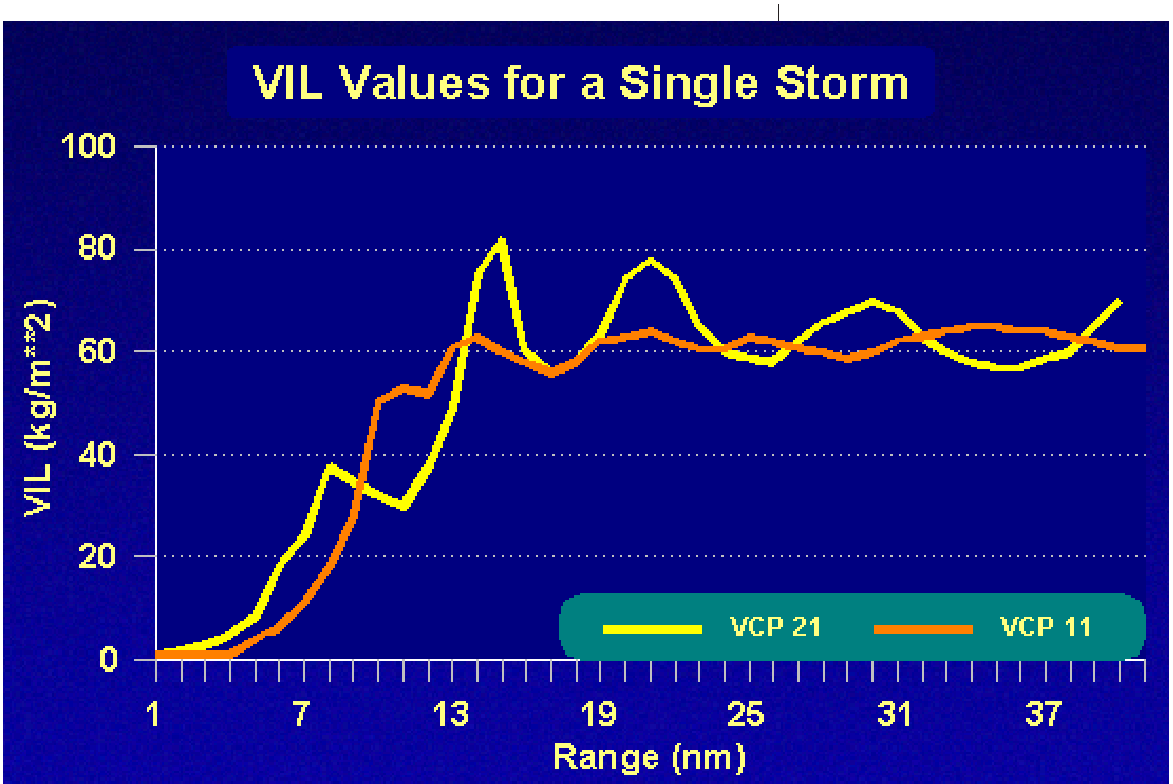


Figure 5-44. This study is from measurements of a single storm using two different volume coverage patterns. The results of the study show that a storm moving toward or away from the RDA will have more fluctuation in VIL values in VCP 21 than in VCP 11. This is due to the fact that there are more gaps in VCP 21 than in VCP 11. This effect is most noticeable within 60 nm of the RDA.

ranges the beam may be cutting through the highly reflective hail cores in the mid levels of a storm producing an overestimation of VIL, or overshooting the convection and underestimating VIL.

VIL Applications (Strengths)

1. **Locate storms with more significant reflectivity cores.**

High VIL values correspond to deep areas of high reflectivity indicative of strong updrafts. VIL Density (VIL divided by Echo Tops - see Amburn and Wolf (1997)[1]) has also shown some skill indicating significant storms. Limitations of VIL previously listed (e.g., storm tilt and fast moving storms) and Echo Tops (later in this lesson) should always be considered when using these values.

2. **Useful for distinguishing storms with large hail once threshold values have been established.**

   Establishing a “VIL of the Day” for hail using climatological data and/or sounding data (see Paxton and Shepherd (1993)[2]) can be of use for initial development, but better skill can be achieved by real-time comparison between VIL values, reflectivity structures and spotter reports. As with all algorithm output, VIL alone should never be used as a warning criteria.

3. **Persistent high VIL values associated with supercells.** The exception is mini-supercell thunderstorms or LP Supercells (see Burgess et al (1995)[3]).

4. **Rapid decrease in VIL values may signify the onset of wind damage.**

   Use caution with this technique. It is important to know which VCP is being used because of gaps in the coverage in VCPs 21 and 121. For more information see An Overview of Operational Forecasting for Wet Microbursts by William P. Roeder (45th Weather Squadron, USAF Cape Canaveral, FL) on the WDTB Web page (http://www.wdtb.noaa.gov/workshop/psdp/Roeder/index.htm).

Digital (High Resolution or 8-bit) VIL (DVL)

The Digital VIL product is **not** a replacement for the existing gridded VIL product. Although it uses a the same equation as VIL to convert reflectivity to kg/m^2, the finer data resolution (1° by 1 km polar format), and lack of truncation has a substantial

[1]Amburn, Steven A., Peter L. Wolf, 1997: **VIL Density as a Hail Indicator.** *Weather and Forecasting*: Vol. 12, No. 3, pp. 473—478.
[2]Paxton, C. H., and J. M. Shepherd, 1993: Radar diagnostic parameters as indicators of severe weather in central Florida. *NOAA Tech. Memo. NWS-SR 149,* 12 pp.
3Burgess, D. W., R. R. Lee, S. S. Parker, D. L. Floyd, and D. L. Andra Jr., 1995:A study of mini supercells observed by WSR-88D radars. Preprints, *27th Conf. on Radar Meteorology,* Vail, CO., Amer. Meteor. Soc., 4—6.

impact on the value. There have been instances where a value of 40 to 45 kg/m^2 on the VIL product equated to a value of 80 kg/m^2 on the DVL product. Any empirical study using VIL (e.g., VIL Density, VIL of the Day, etc.) should **not** be used with the DVL product.

Process

The same equation is used to convert reflectivity to liquid water content:

$$M = 3.44 \times 10^{-3} Z^{4/7}$$

where M = liquid water content (g m-3)

Z = radar reflectivity (mm6 m-3)

The values are derived from each 1 km (0.54nm) x 1 degree, and then vertically integrated. DVL values are output in kg/m^2, and displayed in 256 data levels from 0 to 80 kg/m^2 out to a range of 460 km (248 nm). (See Fig. 5-45 on page 5-80.)

DVL uses **all** reflectivity data available (recall VIL uses only reflectivities above 18 dBZ). There is currently **no truncation** of higher reflectivities (recall VIL truncates reflectivities above 56 dBZ).

DVL Product Characteristics

DVL product legend description:

- RPG ID: kxxx
- PRODUCT NAME: 8-bit VIL
- DATE: Day of week, time, and date in UTC

DVL product annotations

- VCP: 11, 12, 21, 121, 31 or 32

- MX: This is the maximum value in kg/m^2. The location of this value is unknown.

Additional DVL product characteristics

- RANGE: 248 nm
- RESOLUTION: 0.54nm x 1 degree

DATA LEVELS: 256 Data level values range from 0 kg/m^2 to 80 kg/m^2.

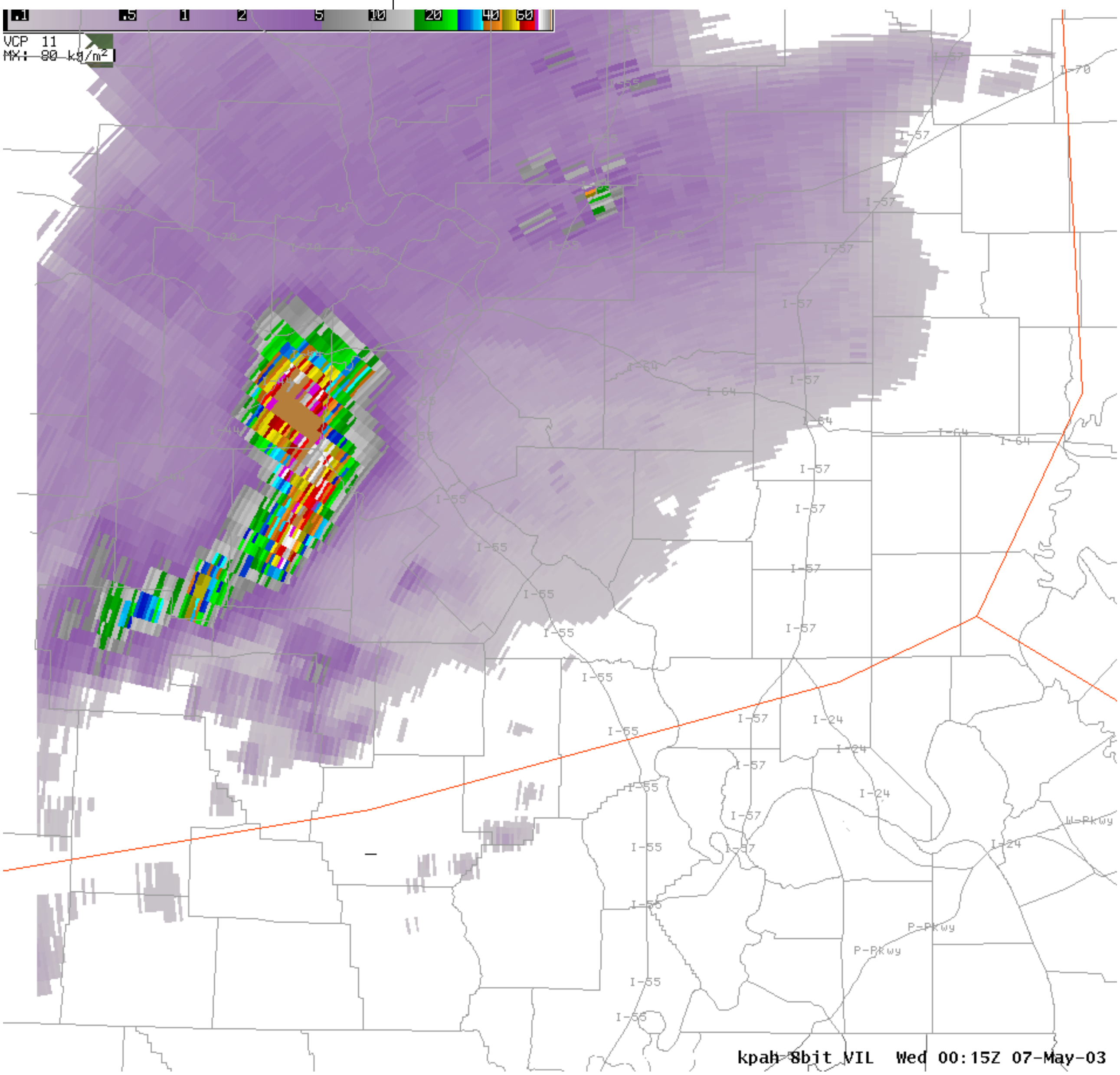


Figure 5-45. Digital VIL (DVL) product in AWIPS.

DVL Limitations

1. **Higher resolution and lack of truncation produces different values when compared to VIL.**
   - VIL research findings (VIL Density, VIL of the Day, etc.) are invalid for DVL.
2. **Fast moving or highly tilted storms will produce lower DVL values than if the same storm was vertical or slow moving.**
   - This has a greater impact on DVL than VIL due to the smaller bin size of DVL (1 km x 1 degree) vs. VIL (4 km x 4 km).
3. **80 kg/m2 (maximum displayed DVL value in AWIPS) is commonly reached due to lack of truncation of high reflectivities.**
   - Since many storms have DVL values of >80 kg/m^2, it is more difficult to isolate the most significant storms.

DVL Applications (Strengths)

1. **Displays low reflectivity features (snow bands, gust fronts, smoke plumes, etc.)**
   - Use of low reflectivities (<18 dBZ) in calculations, and display of VIL less than 1 kg/m^2 allows display of low reflectivity features.
2. **Ground clutter has less impact on DVL than other volume products (e.g., Composite Reflectivity)**
   - The FAA plans to use this product instead of Composite Reflectivity for this reason. Ground clutter has high reflectivities, but they are shallow. The vertical integration lowers the impacts of the highly reflective ground clutter.

Reflectivity Cross Section (RCS)

The WSR-88D can generate a cross-section between any two points within a 124 NM range as long as the points are no greater than 124 nm apart.

Process

The cross section product is a volume product created by:

1. ***Linking all elevation scans*** using 0.54 nm base data.
2. ***Interpolating vertically between elevation angles*** where no data are collected (vertical resolution 0.27nm).
3. ***No extrapolation is performed from highest or lowest elevation angle.*** It uses beam center point height.

Cross section products are not recommended for RPS List since endpoints change constantly.

Product Request

Using Interactive Lines, the user places a line through a storm of interest. Lines are referenced by the letters assigned to the endpoints, e.g. A & A', B & B', etc. The RCS requires a full volume scan of data, it is generated using data from the last completed volume scan. See Figure 5-46 for an example of the request screen for the RCS product.

Product Interpretation

The user selects 2 points (AZRANS) which can be up to 124 nm apart, but within 124 nm of the RDA. On the cross section product, ENDPT1 is always on the left side, ENDPT2 is on the right. It doesn't matter in which order they are picked. ENDPT1 is defined as the western most point picked, unless along the same longitude, then ENDPT1 is the northern point. The RCS is created using data from the last completed volume scan.

Product dimensions

- Height on Z axis is at 10,000 ft intervals (Above Radar Level (ARL)), which cannot be changed.
- Range on X/Y axis depends upon length of cross section. Endpoint AZRAN (Azimuth/

Range) are listed in the annotations area and on the bottom of the cross section.

See Figure 5-47 for an example of the RCS product.

Reflectivity Cross Section (RCS) Product Characteristics

RCS product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Xsect Refl
- UNITS: dBZ

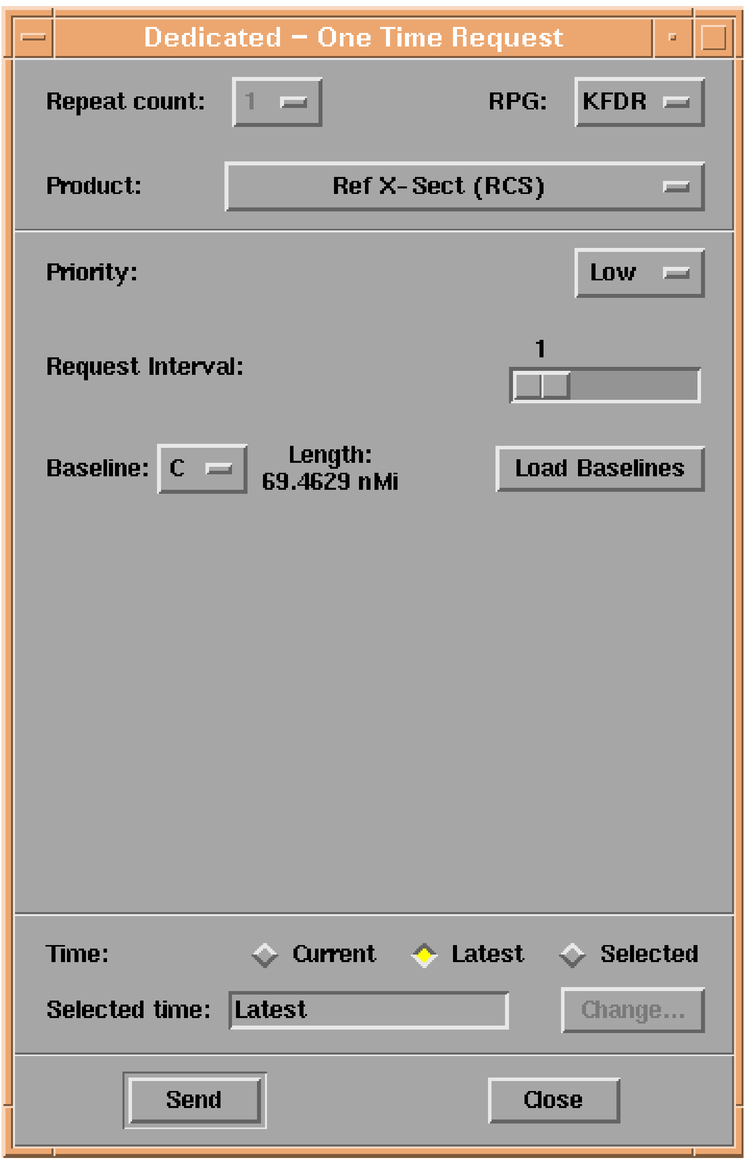


Figure 5-46. RCS product request screen

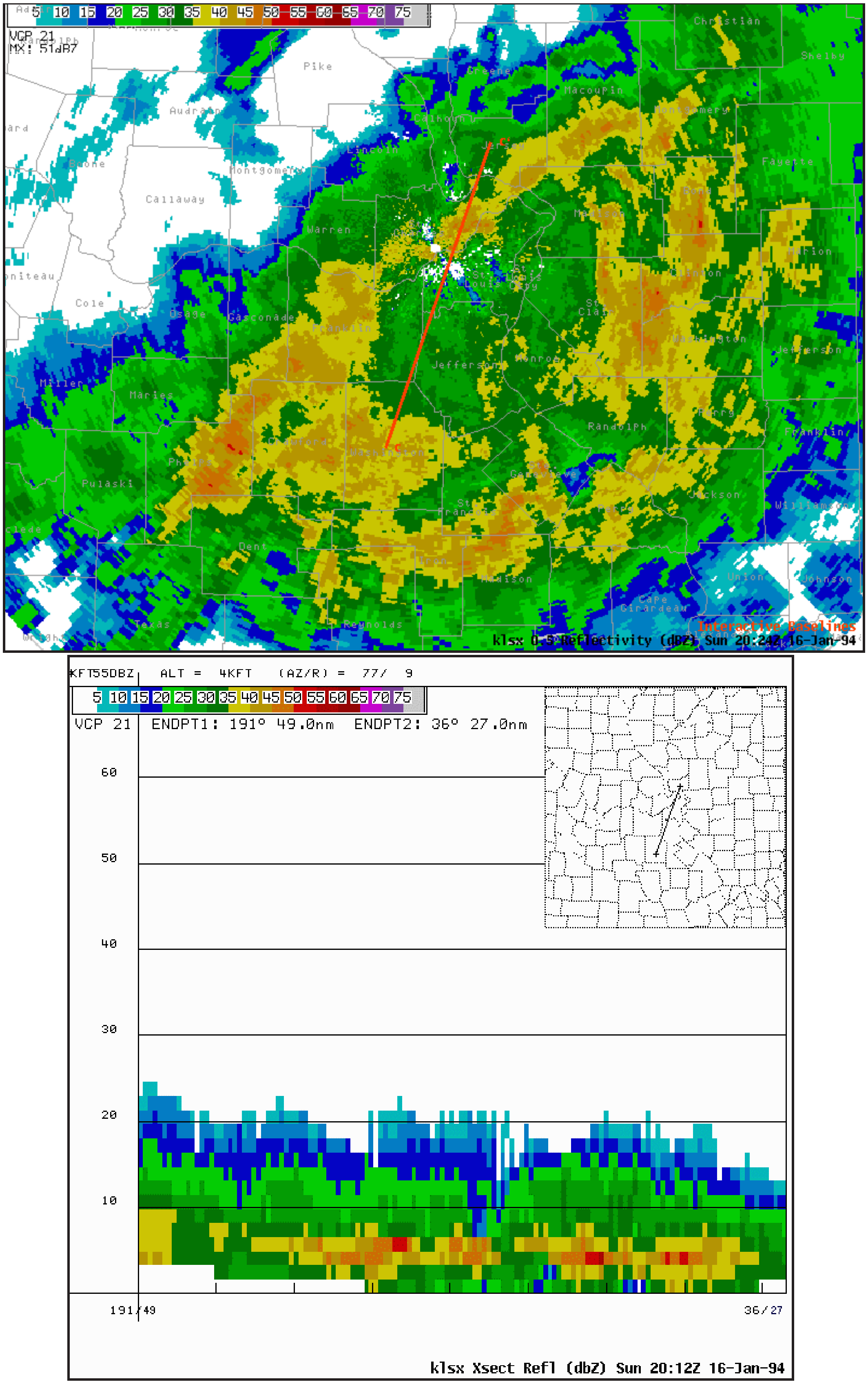


Figure 5-47. Top: Base Reflectivity overlaid with the interactive line used to generate the cross section. Bottom: Matching Reflectivity Cross Section

- DATE: Day of week, time, and date in UTC

RCS product annotations

- VCP: 11, 12, 21, 121, 31 or 32
- ENDPT1: This is the AZRAN of the western-most point.
- ENDPT2: This is the AZRAN of the eastern-most point.
- MAX (dBZ), ALT (Kft), (AZ/R): Max reflectivity in the cross section, its altitude and AZRAN.

Reflectivity Cross Section Limitations

1. ***Cross section placement may hamper evaluation of storm structure.***
2. ***Echo tops and bases are truncated,*** no vertical extrapolation on the highest or lowest elevation angles.
3. ***Height vs. range exaggeration.*** The vertical extent of the product is 70,000 ft (~11.5 nm), while maximum range is 124 nm.
4. ***Small features may be enlarged or missed due to interpolation.***
5. ***Presentation of product dependent upon VCP. More coarse with VCPs 21 and 121 than VCPs 11 and 12.*** Due to more gaps within 60 nm of the radar in VCP 21.
6. ***Fast moving storms may appear to be strongly tilted.*** Because of the time needed to complete a volume scan.

Reflectivity Cross Section Applications (Strengths)

1. ***Detect the vertical extent of clouds/insects/ smoke plumes***.
2. ***Verify existence and location of a bright band.***

3. ***Estimate height of higher dBZ's.*** Placement is critical when attempting to estimate dBZ heights.

4. ***Evaluate storm structure features.*** Again, placement is critical in order to see features such as BWERs, WERs, storm tilt, low echo centroids, TBSSs.

5. ***Estimate echo tops.*** This product will display reflectivities down to 5 dBZ in precipitation mode.

6. **Monitor the formation/dissipation of precipitation events.**

Interim Summary

Vertically Integrated Liquid (VIL)

1. Knowledge of the meteorological environment is necessary to use product effectively.
2. Alerts operator to most significant storms.
3. Effective for detecting storms with 3/4 inch or larger hail.
4. Critical threshold values must be established for differing climatological regions.

Digital VIL (DVL)

1. Different product than VIL with different applications.
2. No truncation of high reflectivities produces a lot of storms with 80 kg/m^2.
3. Displays low reflectivity features such as boundaries, snow bands, smoke plumes, etc.

Reflectivity Cross Section (RCS)

1. Placement is critical to interpretation.
2. Determine storm structure features such as updraft flank, tilt, storm top, WERs, BWERs, and the vertical extent of higher reflectivities.
3. Cross sections must be within 124 nm of radar with a maximum length of 124 nm.

Composite Reflectivity (CZ)

The Composite Reflectivity product displays the highest reflectivity for each grid box for all elevation angles (see Fig. 5-48) .

Resolution

- 1 km x 1 km (.54 x .54 nm) range 124 nm
- 4 km x 4 km (2.2 x 2.2 nm) range 248 nm

Note: There is *no 2 km (*1.1 nm) resolution product

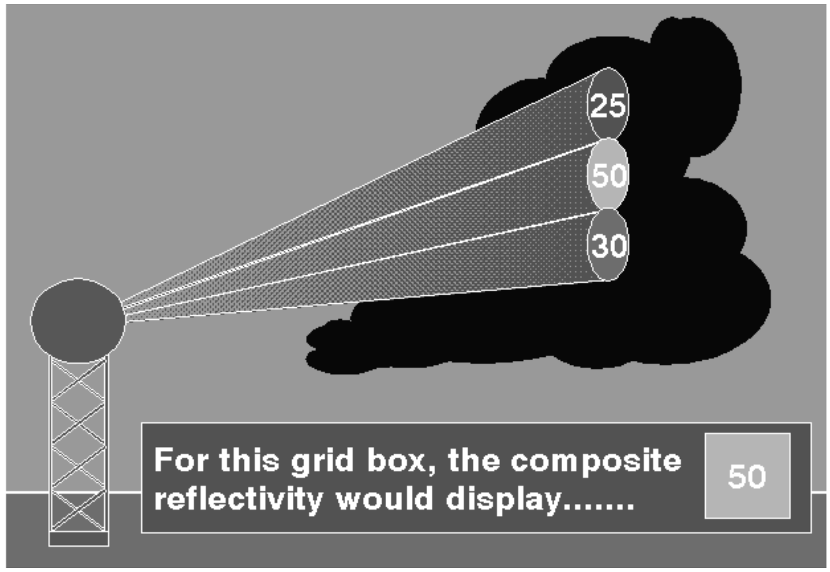


Figure 5-48. Composite Reflectivity

Combined Attributes Table

The Combined Attributes Table is only available on the Composite Reflectivity (See Figure 5-49). The table contains output from the following algorithms:

1. SCIT
2. HDA
3. TVS
4. MESO

```
STORM/ID   AZ/RANTVS  MESO POSH/POH/MX SIZEVILDBZM HTTOPFCST MVMT
           SO    357/ 62 NOYES  70/100/ 1.254659 18.5 32.7 238/ 29
           AO    181/ 90 NO NO 100/100/ 2.506266 20.0 37.7 257/ 33
           C3    160/107 NO NO  80/100/ 1.255361 13.7 35.2 234/ 39
           F3    326/ 16 NO NO  70/100/ 1.253762 15.8>34.0 NEW
```

Figure 5-49. Combined Attributes Table which appears at the top of the Composite Reflectivity product.

Some outside users are only able to access TVS and MESO detections using the Combined Attributes Table. This can lead to confusion since the table only includes azimuth and range to the **storm cell centroid**, not the TVS or MESO location.

The Combined Attributes Table includes:

- **STM ID** - Cell ID letter/number
- **AZ/RAN** - Azimuth and Range of **cell centroid**
- **TVS** - Yes if TVS is present or No
- **MESO** - Yes or no for MESO only. It will always be no for 3-D Correlated Shear, or Uncorrelated Shear (from legacy Mesocyclone product).
- **POSH / POH / MX SIZE** - Probability of Severe Hail / Probability of Hail / Max Hail Size
- **VIL** - Cell Based VIL
- **DBZM HT** - Maximum reflectivity (dBZ) and height of maximum reflectivity (Kft)
- **TOP** - Height of upper most component (Kft)
- **FCST MVMT** - Forecast movement (deg./ kts)

Order of storms

1. TVS or ETVS
2. Mesocyclone, 3DC Shear, Uncorrelated Shear
3. Probability of Severe Hail (POSH)
4. Probability of Hail (POH)
5. Cell based VIL

Note: Cells with unknown POSH or POH (i.e., cells beyond 124nm), yet high cell based VIL, may end up at the bottom of the Combined Attributes Table.

Composite Reflectivity (CZ) Product Characteristics

See Figure 5-50, 5-51, and 5-52 for examples of the CZ product.

CZ product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Composite Ref
- UNITS: dBZ

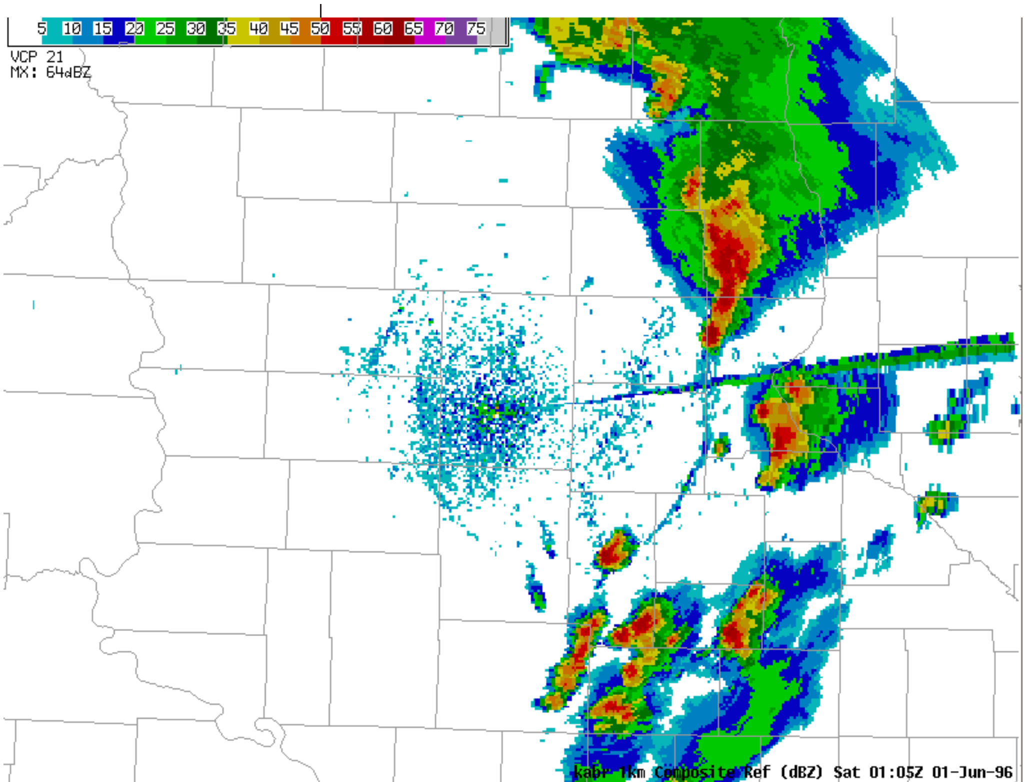


Figure 5-50. 0.54 nm resolution.

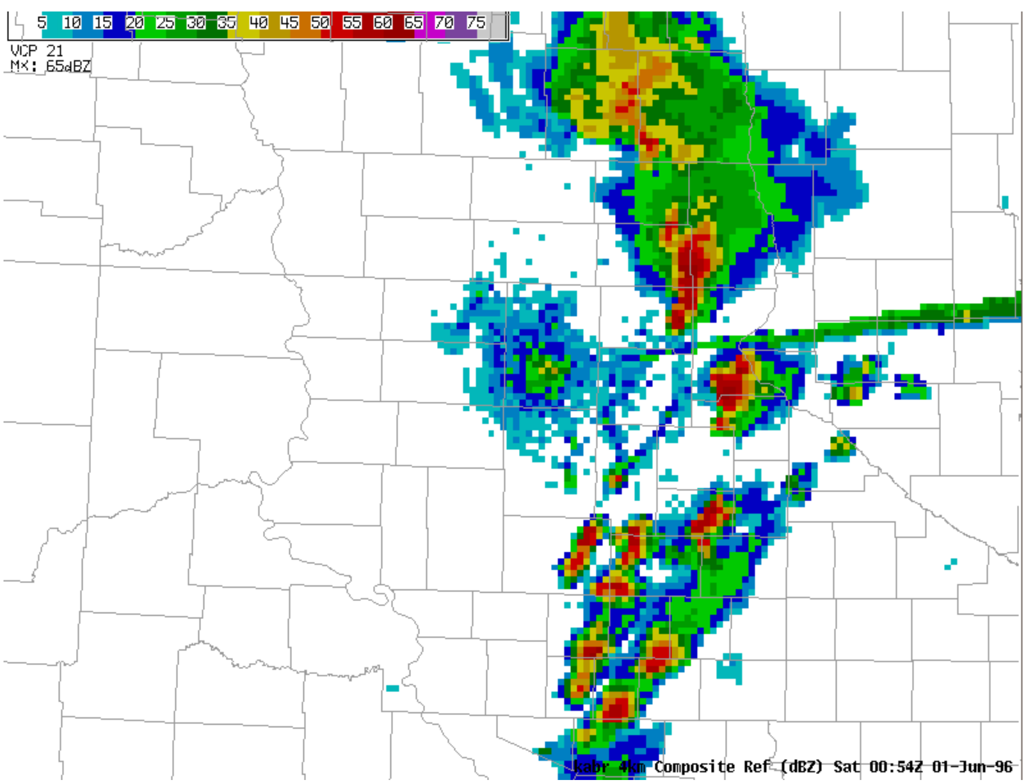


Figure 5-51. 2.2 nm resolution

- DATE: Day of week, time and date in UTC

CZ product annotations

- VCP: 11, 12, 21, 121, 31 or 32
- MX: This is the maximum reflectivity (dBZ) on the product, with the location unknown. This value will not change when zoomed in on a feature, as it is the maximum value for the entire product (Note: RPG Build 7 bug displays MX at 95 dBZ - to be fixed in RPG Build 8).

Additional CZ product characteristics

- RANGE: 124 or 248 nm
- RESOLUTION: .54 or 2.2 nm, respectively
- DATA LEVELS: 16 data levels - values range from 5 to 75 dBZ

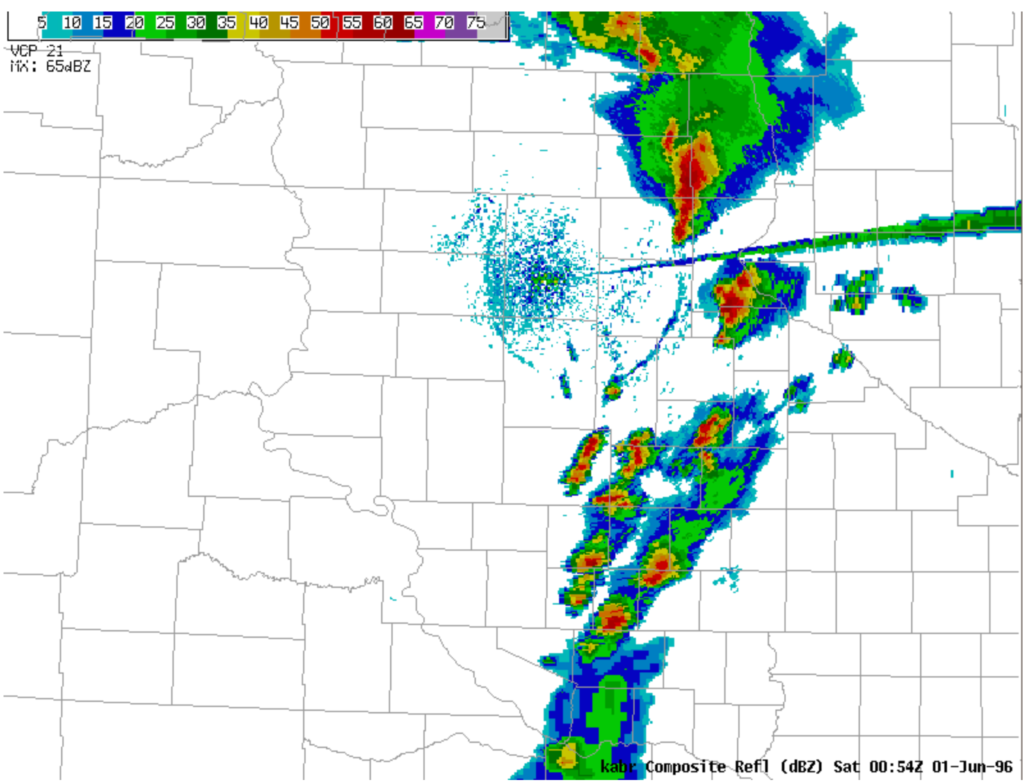


Figure 5-52. Composite Reflectivity (CZ) product showing both resolutions.

Composite Reflectivity Limitations

1. **Low level reflectivity signatures are obscured.**
2. **Height of reflectivity is unknown.**
3. **Echo aloft can't be discriminated from precipitation reaching the surface.**
4. **Non-precipitation echoes may contaminate product.**

Composite Reflectivity Applications (Strengths)

1. **Reveals highest reflectivity in all echoes.**
2. **Determine storm structure features & intensity trends in storms.** (When compared with base products).
3. **Generate cross sections through maximum reflectivity knowing the inflow side of storm.** The operator will have more predictable results with a .54 nm product.
4. **The Combined Attributes Table is available.**

Layer Composite Reflectivity Maximum (LRM)

Displays the highest reflectivity value of all elevation angles for each 2.2 x 2.2 nm grid box in a layer.

Three layers

- **Low** (Layer 1) **-** Just above radar level to 24,000 ft
- **Mid** (Layer 2) **-** 24,000 ft to 33,000 ft
- **High** (Layer 3) **-** 33,000 ft to 60,000 ft

The depths of these products are fixed. If different layers are desired use the User Selectable Layer Reflectivity (ULR) product described next.

Originally developed for CWSU/FAA use.

Desired product layers (L,M,H) can be specified on the RPS list or one time request.

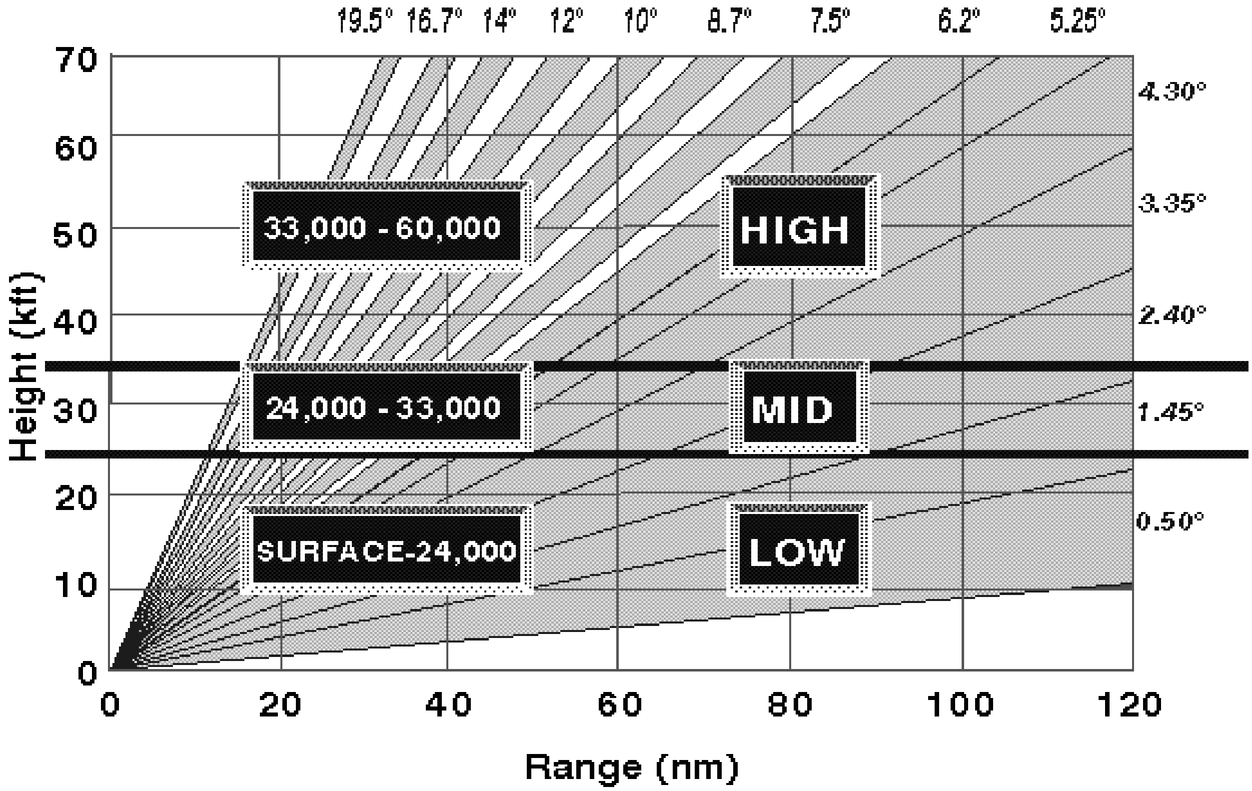


Figure 5-53. Layer Composite Reflectivity Default Layers (VCP 11)

Resolution 2.2 x 2.2 nm; Coverage **248 x 248 nm** .(See Fig. 5-54 on page 5-93.)

Available with **8** data levels only

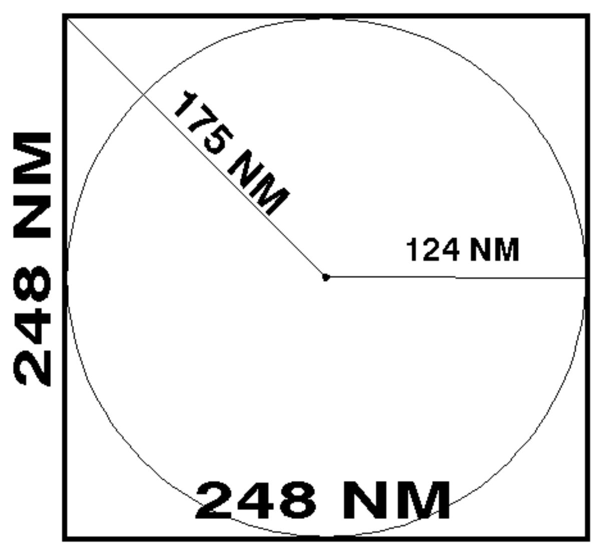


Figure 5-54. LRM/LRA Product size.

LRM Product Characteristics

See Figure 5-55 for an example of the LRM product.

LRM product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Layer 1 (2 or 3) Max Refl
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

LRM product annotations

- VCP: 11, 12, 21, 121, 31 or 32
- BOT: Bottom of the layer in kft
- TOP: Top of the layer in kft
- MX: This is the maximum reflectivity (dBZ) on the product, with the location unknown. This value will not change when zoomed in on a feature, as it is the maximum value for the entire product.

Additional LRM product characteristics

- RANGE: 124 nm
- RESOLUTION: 2.2 x 2.2 nm
- DATA LEVELS: Data level values are fixed at 5, 18, 30, 41, 46, 50, 57 dBZ

LRM Limitations

1. **Mid & Low layer products will use few elevation angles at long distances.**
2. **Mid and High level products are ineffective at close range due to the cone of silence.**
3. **Low layer product susceptible to non-precipitation echoes.**

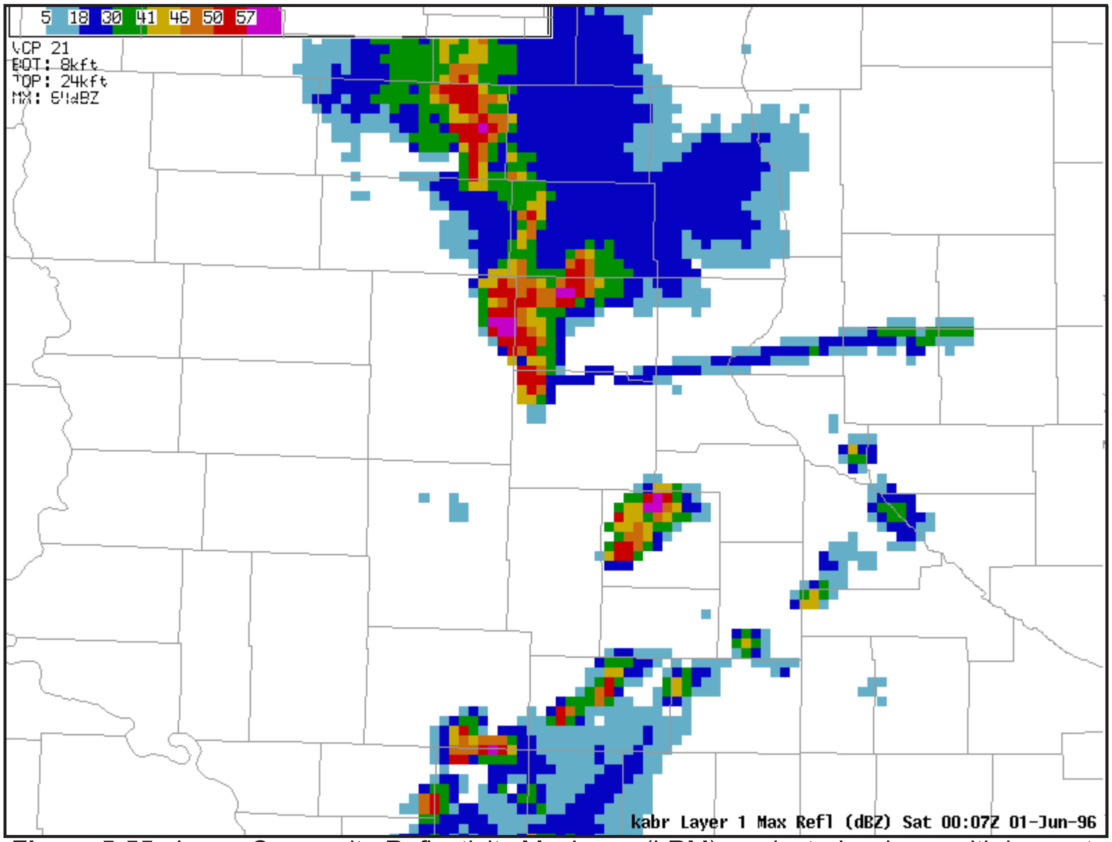


Figure 5-55. Layer Composite Reflectivity Maximum (LRM) product - low layer with base at 8,000 ft MSL.

LRM Applications (Strengths)

1. **Mid-High layer products used to estimate the height of higher reflectivities.**
2. **Comparison of Base Reflectivity and Mid or High Layer Composite Reflectivity Maximum product may aid in determining a storm's intensity trend.**
3. **Use mid level product to help differentiate real echoes from ground clutter.**

User Selectable Layer Reflectivity Maximum (ULR)

The User Selectable Layer Reflectivity Maximum (ULR) product allows the user to select a specific, customized layer of reflectivity. The ULR offers the capability for the user to select both the lower and upper levels to design a product which will meet various forecasting needs such as a better understanding of storm structure and potential levels of icing (Bright Banding).

ULR Product Characteristics

The minimum thickness of the selected layer is 1 kft and altitudes from 0 to 70 kft may be selected. The ULR is a polar gridded product (note the LRM and LRA products are rectangularly gridded). The ULRs resolution is 1 km (.54 nm) x 1° and has a range of 230 km (124 nm). You can select the ULR to be generated for up to 9 volume scans. (See Fig. 5-56 on page 5-96.) Non-associated Users can only get previously generated products by doing one-time requests.

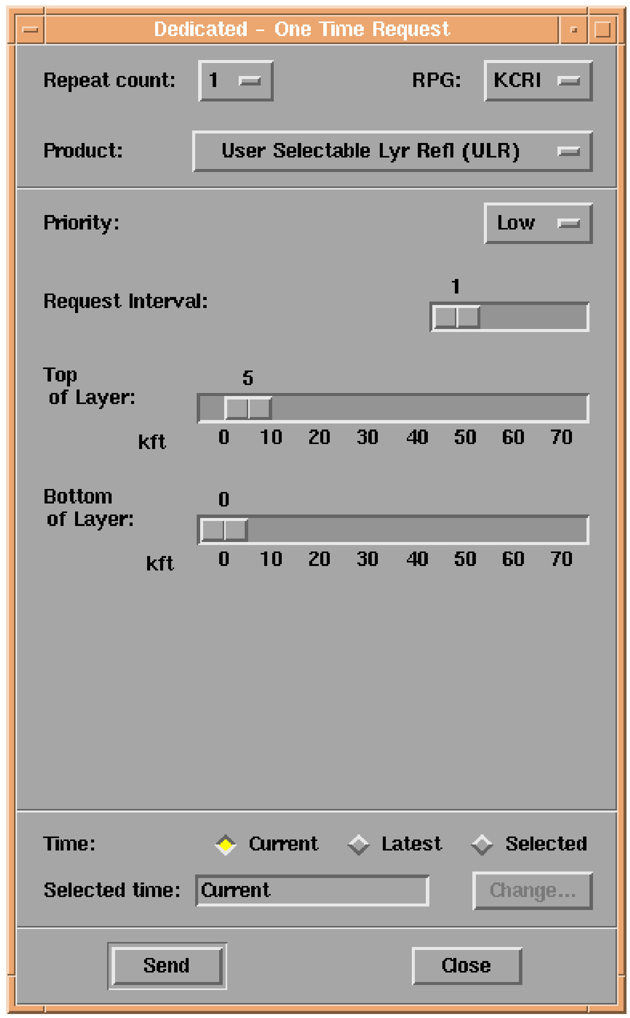


Figure 5-56. User Selectable Layer Reflectivity Maximum (ULR) One Time Request Window.

ULR Example(See Fig. 5-57 on page 5-98.)

ULR product legend description:

- RPG ID: kxxx
- PRODUCT NAME: User Selectable Refl
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

ULR product annotations

- VCP: 11, 12, 21, 121, 31 or 32
- BOT: Bottom of the layer in kft
- TOP: Top of the layer in kft
- MX: This is the maximum reflectivity (dBZ) on the product, with the location unknown. This value will not change when zoomed in on a feature, as it is the maximum value for the entire product
- Additional ULR product characteristics
- RANGE: 124 nm
- RESOLUTION: 1° x 0.54 nm
- DATA LEVELS: 16 data levels

ULR Limitations

1. **Height of data within selected layer is unavailable.**
2. **Shallow layers will often have concentric circles (stepped appearance) due to limited number of slices through layer.**

ULR Applications (Strengths)

1. **Layer can be selected to meet user needs.**
2. **Has higher resolution and more data levels than LRM products.**
3. **Can be used to locate bright band.**
4. **Help locate storms with significant hail threat by requesting layer centered on -20oC**

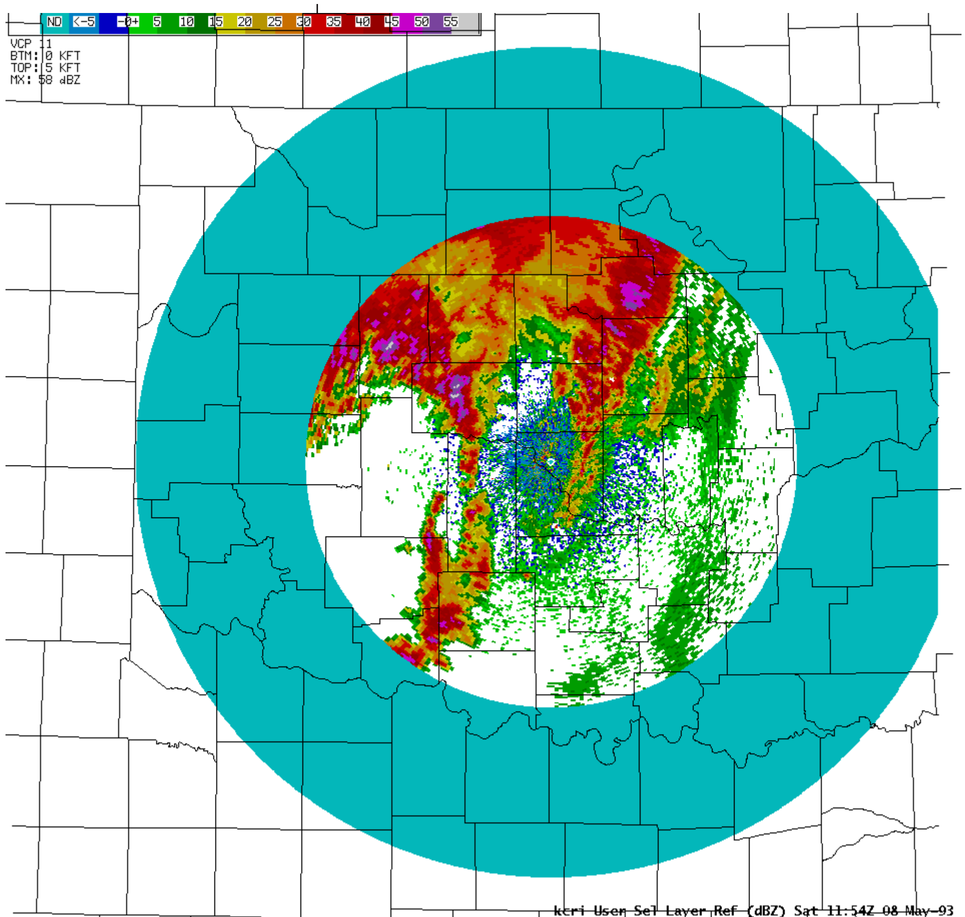


Figure 5-57. User Selectable Layer Reflectivity (ULR) product

Enhanced Echo Tops (EET)

Definitions

Cell Top - Height of highest component (>30 dBZ) above radar level (ARL)

Echo Top - Height of the 18 dBZ (default) echo in MSL.

Process

The Enhanced Echo Top product is an estimate of the maximum height of the ***18 dBZ*** (default) echo for each ***0.54 nm x 1 degree grid box.*** Interpola-

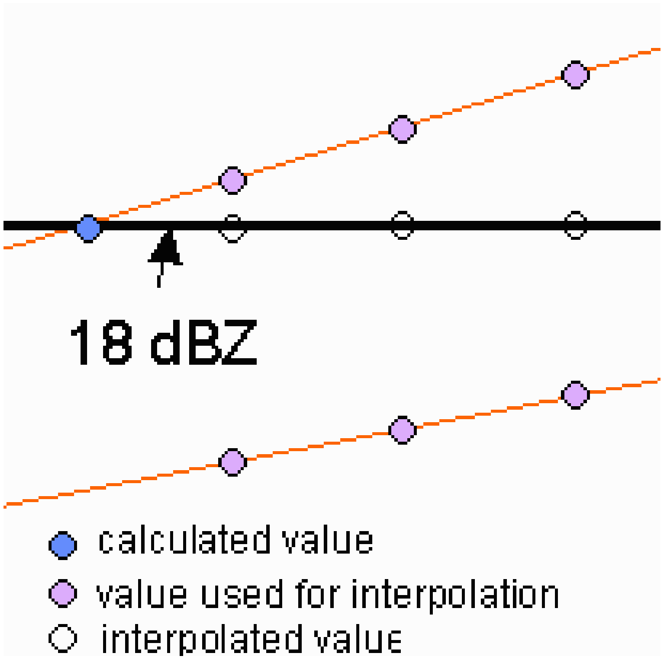


Figure 5-58. Interpolation between elevations in EET product

tion occurs between elevations slices (see Fig. 5-58).

If no data exists on the higher angle, then a value of -10 dBZ is used for the interpolation. If any data is available (as low as -28 dBZ) on the higher angle, then that value (i.e., -28 dBZ) is used in the interpolation.

In areas where reflectivities exceed 18 dBZ on the highest elevation angle (i.e., 19.5 degrees in VCP 11, 12, 21, 121) the height is tagged as “topped”. See Figure 5-59 for an example of the EET product.

EET Product Parameters

EET product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Enh Echo Tops
- UNITS: kft
- DATE: Day of week, time, and date in UTC

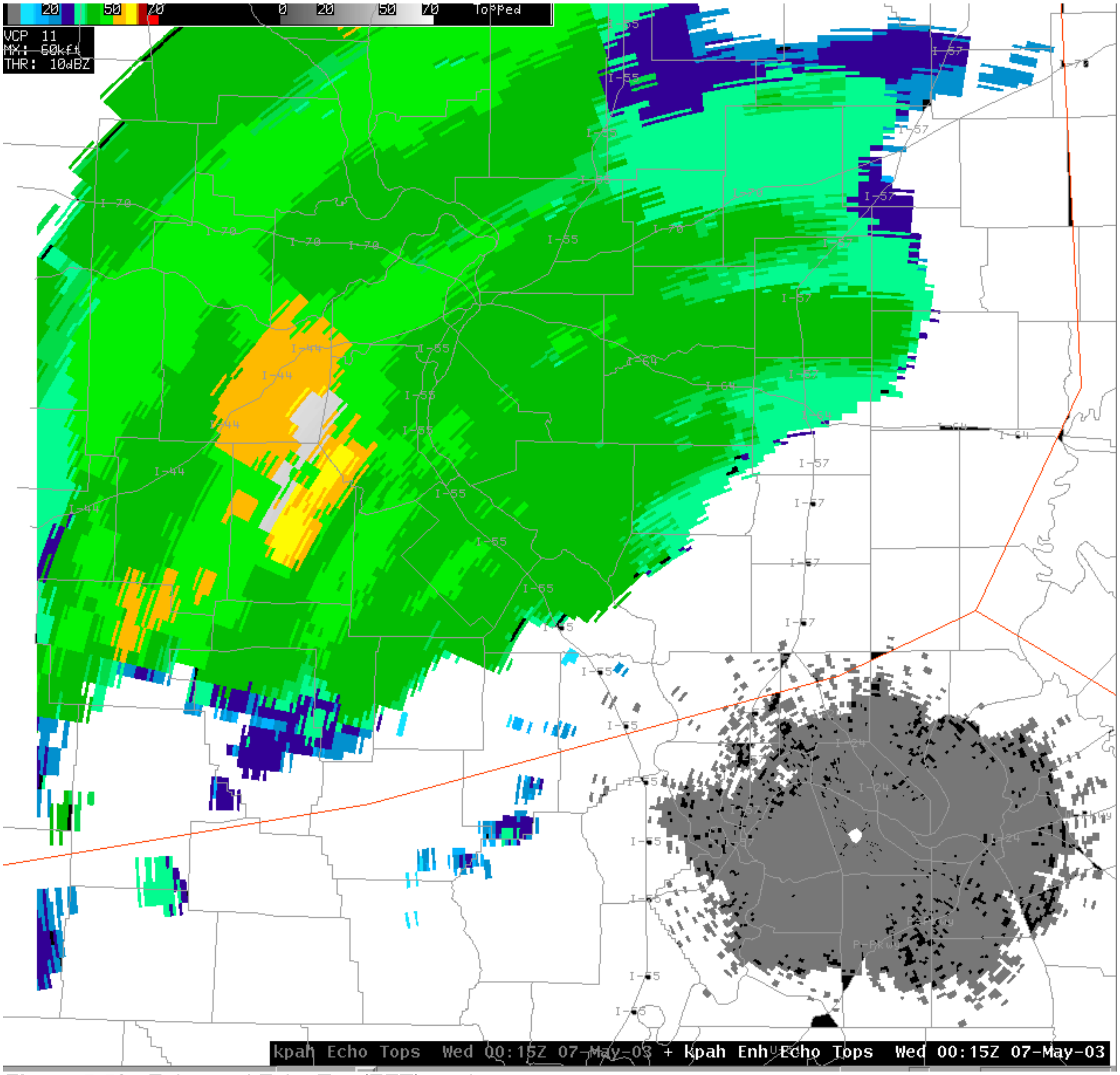


Figure 5-59. Enhanced Echo Top (EET) product

EET product annotations

- VCP: 11, 12. 21, 121, 31 or 32
- MX: This is the maximum height (kft) on the product, with the location unknown. This value will not change when zoomed in on a feature, as it is the max value for the entire product.

- THR: This is the threshold used to define the echo. Default is 18 dBZ.

Additional EET product characteristics:

- RANGE: 124 nm
- RESOLUTION: 0.54 nm (1 km) x 1 degree
- DATA LEVELS: 256 Data levels - values range from 0 kft to 70 kft with separate color scale (usually gray scale) for “topped” 0 kft to 70 kft

EET Limitations

1. ***A circular stair-stepped appearance will often be evident*** due to use of discrete elevation sampling (see Fig. 5-59).

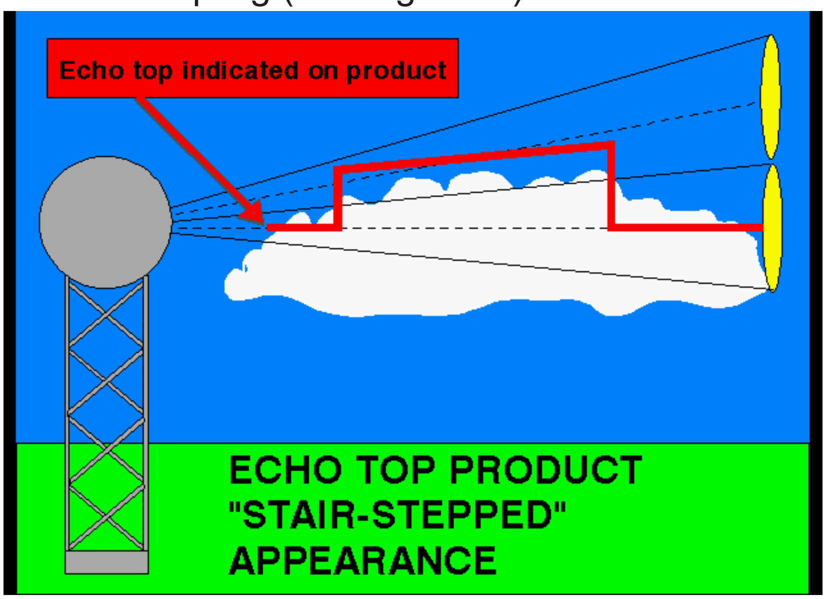


Figure 5-60. Echo Top product stair-stepped appearance.

2. **Side lobes may result in <u>overestimated</u> tops.**
3. **Tops will be underestimated close to the radar due to the cone of silence (coded as “topped”).**

EET Applications (Strengths)

1. **Quick estimation of the most intense convection; higher echo tops.**
2. **Assist in differentiating non-precipitation echoes from real storms.**

3. **Aids in identification of storm structure features such as tilt, updraft flank, max top over strong low level reflectivity gradient, etc.**
4. **May detect mid-level echoes before low-level echoes are detected.**

Interim Summary

1. Displays the maximum reflectivity for each vertical resolution grid box. **2.** Useful product to: • quickly identify most intense storms, & • determine where to create Reflectivity Cross Sections. **3.** Combined Attributes Table is available with product.	**Composite Reflectivity (CZ)**
1. Maximum reflectivity for a specified layer. **2.** Mid or high layer product used to estimate height of higher reflectivities **3.** Comparison of mid or high layer products and Base Reflectivity may help determine the intensity trend of storms.	**Layer Composite Reflectivity Maximum (LRM)**
1. Layer can be selected to meet user needs, such as bright band detection. **2.** Has higher resolution and more data levels than LRM products.	**User Selectable Layer Reflectivity (ULR)**
1. Estimates height in MSL of $\geq$ 18 dBZ echo using interpolation between elevation angles. **2.** Primary use of product is to identify storms with greater vertical development. **3.** Aid in differentiating real echoes from non-precipitation echoes.	**Enhanced Echo Tops (EET)**

Lesson 4: Velocity Based Algorithms and Products

Overview

Velocity Derived Products are those which use the Base Velocity Data as their primary input. The benefit of these algorithms is that they quickly analyze the entire volume scan of velocity data and give the operator guidance as to which areas need additional investigation. Keep in mind that the Base Velocity Data used in these algorithms has already undergone dealiasing as well as range-unfolding before being ingested. As a result, problems such as dealiasing failures or range folding will occasionally make it more difficult for the Velocity Derived Algorithms to produce accurate information

Review

The WSR-88D measures only radial velocity See Fig. 5-61.

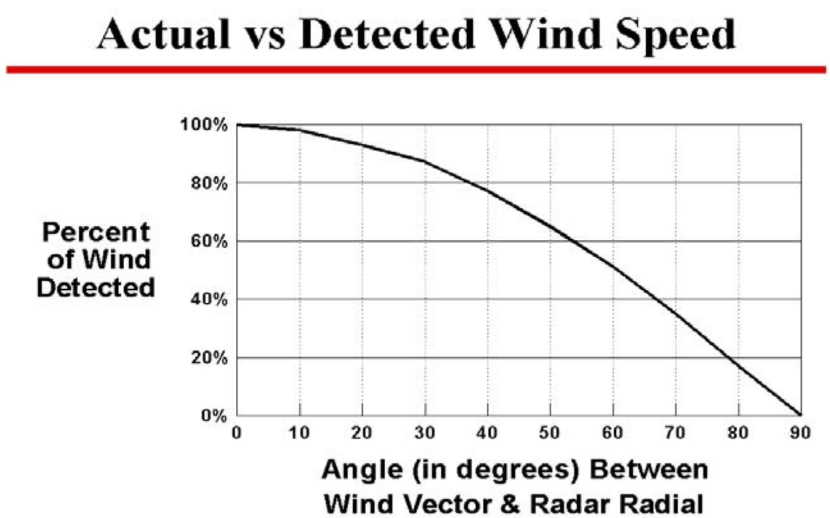


Figure 5-61. If the wind direction is directly down the radial, 100 percent of the velocity will be measured. If it is blowing perpendicular across the radial, 0 percent will be measured. Always keep this in mind when estimating wind speed from Doppler velocities.

Knowledge of where the RDA is in relation to the feature is also very important for proper interpretation. Use of the Polar Grid background map may help the operator to locate the radar when magnification is done.

Here is a quick review of some small scale signatures and their positions relative to the radar (see Fig. 5-62). Notice how the signatures look the same, but because the are in different locations relative to the radar, they would be interpreted differently.

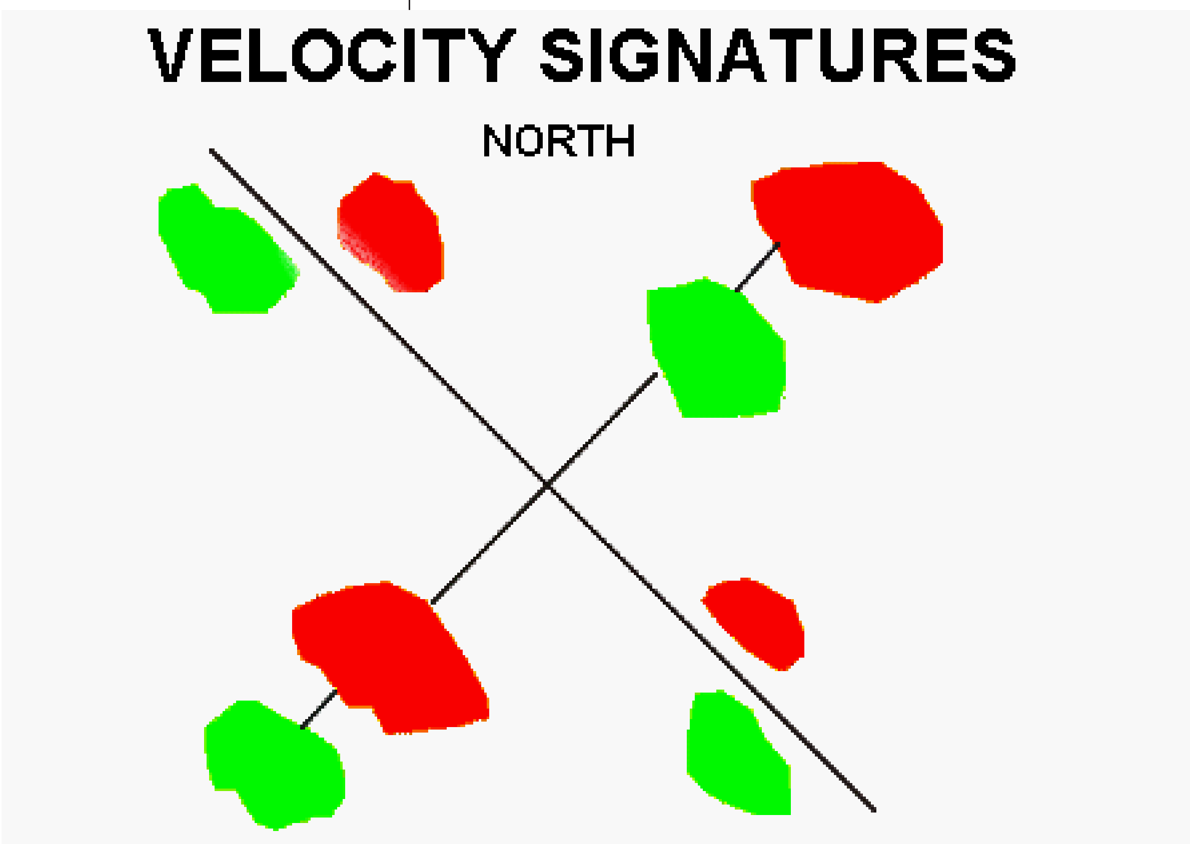


Figure 5-62. Small scale signatures.

Objectives

Upon completion of this lesson, you will be able to identify specific characteristics, limitations, and applications (strengths) of the following products:

1. 8-Bit Storm Relative Mean Radial Velocity Map (SRM)
2. Velocity Cross Section (VCS)
3. Velocity Azimuth Display (VAD)

4. Velocity Azimuth Display Wind Profile (VWP)

5. Mesocyclone Detection (MD)

6. Tornadic Vortex Signature (TVS)

7. TVS Rapid Update (TRU)

Storm Relative Mean Radial Velocity Map (SRM)

SRM Overview

A long name which will be shortened to SRM from here on out! The SRM is a 124 nm radius product of mean radial velocity with an estimated storm motion subtracted out.

In the example, (see Fig. 5-63 on page 5-108) the identical mesocyclone is displayed using a Base Velocity product (left) and the SRM Product (right). The storm is moving to the northeast at 40 kts. The Base Velocity is measuring both the circulation and the storm motion. Therefore, all we see is outbound velocities (much stronger on the right side of the couplet). In the SRM, we take away the motion of the storm itself, leaving only the circulation. The couplet is now very apparent to the observer showing the classic signature for pure rotation. Unless you are very experienced, you might not suspect a circulation is present using base velocity alone. However by looking at the SRM, you can now take steps to evaluate the strength of the circulation and determine a course of action.

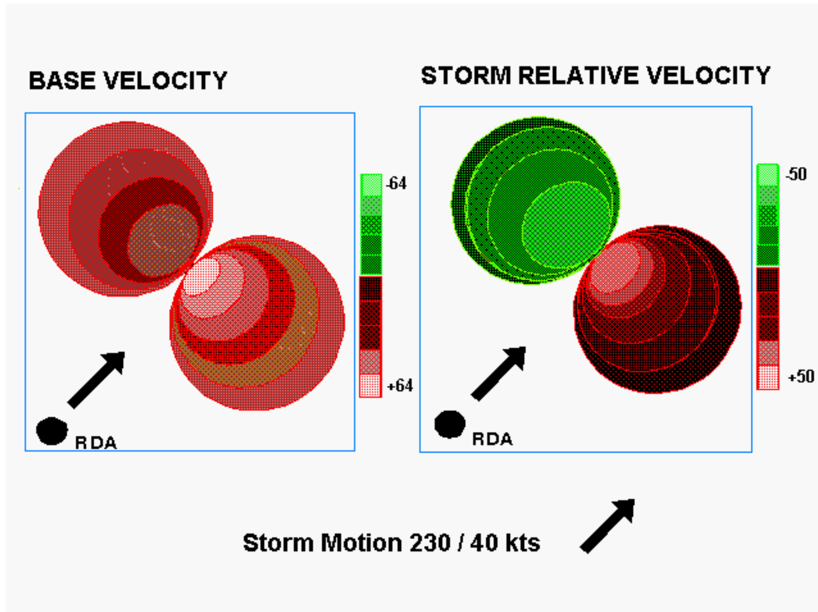


Figure 5-63. When storm motion is subtracted, circulations are easier to see.

Default Storm Motion

Estimated storm speed and direction used by the algorithm will default to the ***average motion of all storms*** from the Storm Track Information Product (from the previous completed volume scan). Keep in mind the limitations of the SCIT algorithm which can cause erroneous storm motions to be generated. If these errors occur, they will be passed along to this algorithm.

Operator Input Storm Motion

To override this, speed and direction can be input by an AWIPS operator on a one-time request basis to an associated RPG. (See Fig. 5-64 on page 5-109.) The Repeat Count Function may be used. Only SRM with the default motion subtracted can be received from Non-associated RPGs.

Note: The One-Time Request window is used to input operator defined motions for the standard (4-bit) SRM products. A different window or Graphical

User Interface (GUI) is used to input a user defined motion for the 8-bit SRM covered next.

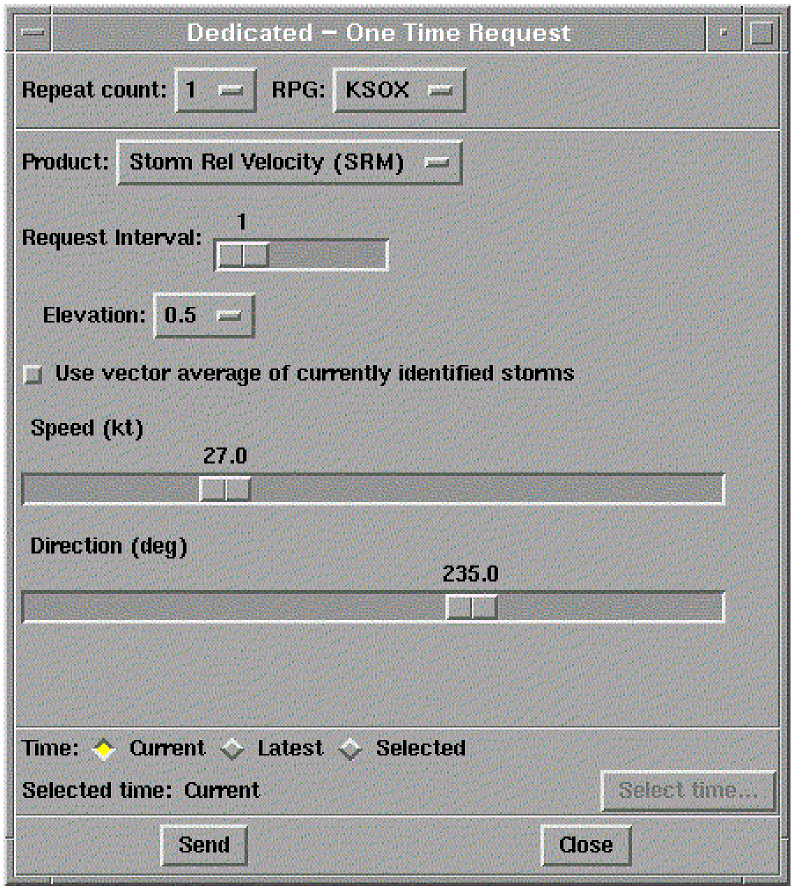


Figure 5-64. Operator input storm motion of 235° at 27 kts.

Product Uses

SRM is useful in detecting shear regions

1) Mesocyclone

2) TVS

3) Upper level divergence

What feature are you attempting to see? When using Storm Relative products you should always consider your frame of reference. If you are interested in the rotation within a storm, use Storm Relative products. If you are interested in ground

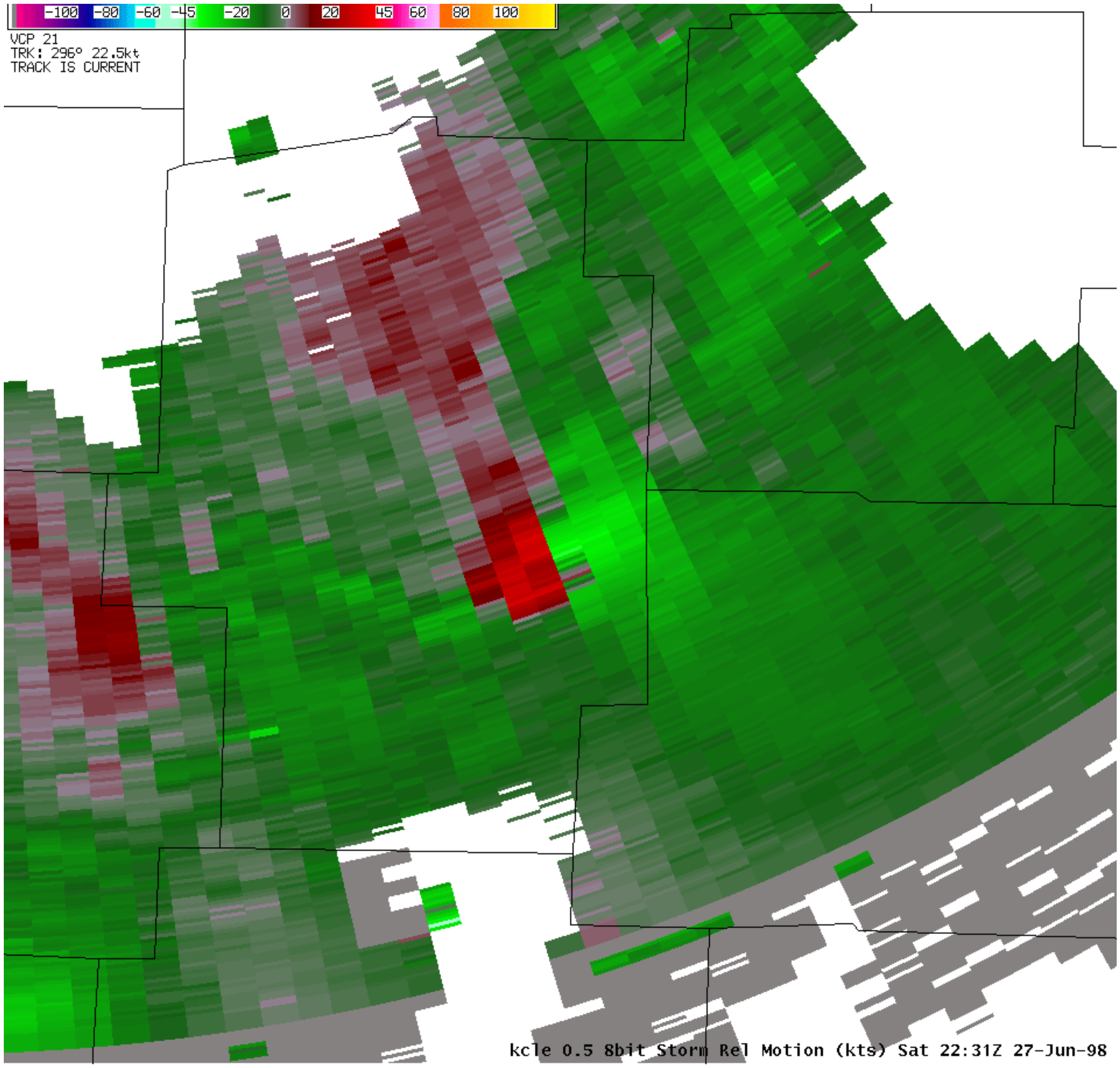


Figure 5-65. Storm Relative Mean Radial Velocity Map (SRM) product (8-bit)

relative winds, (i.e., winds associated with a gust front) use the base velocity products.

8-bit SRM

For example see Figure 5-65.

Process

The 8-bit (256 data level) SRM is a display produced "on-the-fly" by AWIPS using data from the 8-bit Base Velocity product. The 8-bit SRM is not a product produced by the RPG, therefore it is not archived as such. To obtain an 8-bit SRM display you must first have the corresponding 8-bit Velocity product in the AWIPS data base, by either including the 8-bit Velocity on the RPS list or by One-Time Request.

The 8-bit SRM storm motion can be set three ways:

1. The last storm motion set by WarnGen or the distance speed tool.
2. The average storm motion calculated by SCIT. (Same as the default storm motion for the regular 4-bit SRM)
3. Operator motion as set in the Radar Storm Motion Vector graphical user interface.

The decision on which of these three methods are used to set the storm motion is made by the user using the Radar Display Controls. (See Fig. 5-66 on page 5-112.)

Product Uses

The 8-bit SRM product displays the highest resolution velocity data available from the radar out to 124 nm. When compared to the standard 4-bit SRM, it has greater detail spatially and in data magnitudes.

Product Description

8-bit SRM product legend description:

- RPG ID: kxxx
- ELEVATION ANGLE: in degrees (any one in current VCP)
- PRODUCT NAME: 8-bit Storm Rel Vel - Map
- UNITS: kts (nautical miles per hour)
- DATE: Day of week, time, and date **in UTC**

8-bit SRM product annotations:

- VCP: VCP 11, 12, 21, 121, 31 or 32

- TRK: This is the storm motion which has been subtracted out (average of all identified cells). The direction in degrees and speed in kts.
- TRACK IS Current: This is the user supplied (either from Radar Display Controls or from WarnGen) storm motion which has been subtracted out. The direction in degrees and speed in kts.
- TRACK is Default: This is the SCIT Algorithm supplied storm motion. The average cell motion of all SCIT identified cells.

Additional 8-bit SRM product characteristics

- RANGE: 124 nm

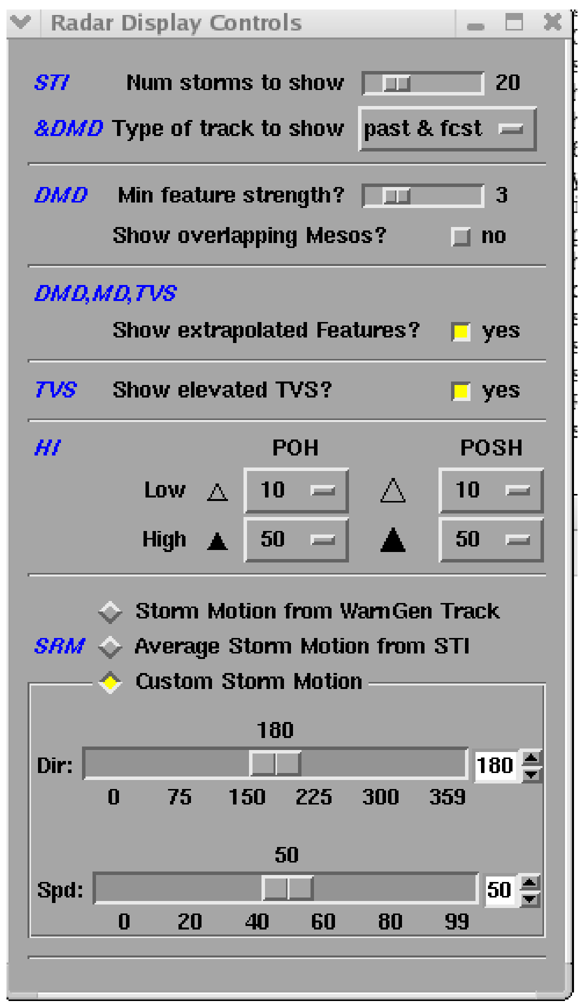


Figure 5-66. Operator input storm motion of 180° at 50 kts.

- DATA LEVELS: 256 (default ± 100 kts)
  - Usually defaults to purple or white for range folded data.

8-Bit SRM Limitations

1. **Care must be taken to ensure a representative storm motion is being used.** Default motion may not be representative.
2. **It is more difficult to determine actual ground-relative winds**.
3. **The 8-bit Base Velocity products used by AWIPS to produce the 8-bit SRM are large** and can produce narrowband load shedding unless a LAN-to-LAN connection is used.

8-bit SRM Applications (Strengths)

1. **High detail both spatially and in data magnitude can provide improved detection of TVSs, Mesocyclones, Microbursts, and Boundaries.**
2. **Same data levels and color scales can be used for both Clear Air Mode and Precipitation Mode VCPs.**
3. **High Storm Relative Velocities (up to 248 kts) are displayable** and viewable on cursor readout sampling.
4. **Very useful for examining the velocity structure of fast moving storms** (> 10 knots).

4-bit SRM Product Description:

SRM 4-bit product legend description:

- RPG ID: kxxx
- ELEVATION ANGLE: in degrees (any one in current VCP)
- PRODUCT NAME: Storm Rel Vel - Map
- UNITS: kts (nautical miles per hour)
- DATE: Day of week, time, and date **in UTC**

SRM product annotations:

- VCP: VCP 11, 12, 21, 121, 31 or 32
- ALG: This is the default storm motion which has been subtracted out (average of all identified cells). The direction in degrees and speed in kts.
- USR: This is the user supplied storm motion which has been subtracted out. The direction in degrees and speed in kts.
- MN: This is the strongest inbound (negative) velocity detected on the product. The location of this value is unknown, and this is a Storm Relative value.
- MX: This is the strongest outbound (positive) velocity detected on the product. The location of this value is unknown, and this is a Storm Relative value.

Additional SRM product characteristics

- RANGE: 124 nm
- DATA LEVELS:
  - 16 data levels from -50 kts to +50 kts, with one level (usually purple or white) for range folded data.
  - Data levels cannot be changed on the SRM.
  - Data levels are ***lower bound***. (For example, 22 kt data level can range from 22-29 kts.)

To investigate a storm three-dimensionally, it is recommended that you put several cuts on your RPS List to be viewed in a 4-panel presentation or all slices to be viewed in the all tilts mode. The slices you choose should be the same as those selected for Base Reflectivity products on your RPS List. The angles you choose will of course depend on the vertical extent of the storm as well as the range to the storm.

4-bit SRM Limitations and Applications (Strengths)

The strengths and limitations for the 4-bit SRM products are essentially the same as for the 8-bit products, only resolution is less and the displayable magnitudes of the velocity values are less, both making the 8-bit SRM more useful. However, the 4-bit products file sizes are much smaller, and therefore require less bandwidth, and do not necessarily need user input for storm motion.

Velocity Cross Section (VCS)

VCS Overview

The Velocity Cross Section is a cross section of the Base Velocity data. This product is produced in a similar manner as the Reflectivity Cross Section (RCS). ***Interpolation*** is used to fill data gaps. Although the horizontal resolution of the product is 0.54nm, the VCS uses the maximum value of every four 0.13nm range bins. Therefore, values displayed on the VCS may appear higher than on the 0.54nm Base Velocity products.

As with RCS, the two points picked must be within 124 nm of the RDA and no more than 124 nm apart.

Since radial base velocity data is used to produce the VCS, it is strongly suggested that the VCS be generated using two points either***:***

- ***along a radial*** to see convergent/divergent signatures and/or updraft/downdraft interface
- ***over a short distance perpendicular to the radial*** to see rotation.

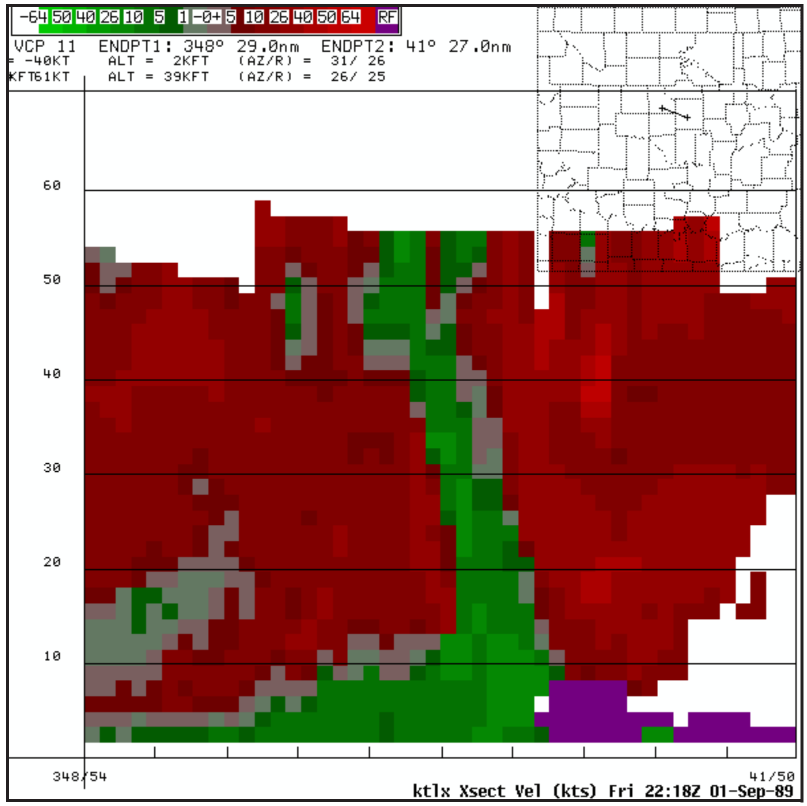


Figure 5-67. Velocity Cross Section (VCS) product. Note geographic location in upper right corner.

Useful product, but not recommended for RPS list - Use this as a supplemental product, particularly in a research mode.

VCS Adaptable Parameters

If the user changes the velocity data levels for the Base Velocity products ***at the RPG HCI***, this will also change the data levels for the VCS.

VCS Product Characteristics

The Velocity Cross Section has the following characteristics:

- RESOLUTION: 0.54 nm horizontal res X 0.27 nm vertical res.
- COVERAGE: 124nm X 70,000 ft
- DATA LEVELS: 8 or 16 data levels
- Height on Z axis in 10,000 ft intervals.
- Range on x/y axis depends upon length of cross section (the endpoints are in km).

- Left side of product is western most point chosen (ENDPT1), unless along the same longitude, then the northern point will be on the left side (ENDPT2).

VCS Product Parameters

See Fig. 5-67 on page 5-116 for an example of the VCS Product.

VCS product legend description

- RPG ID: kxxx
- PRODUCT NAME: Xsect Vel
- UNITS: kts
- DATE: Day of week, time, and date in UTC

VCS product annotations

- VCP: 11, 12, 21, 121, 31, or 32
- ENDPT 1: AZRAN of the western-most point (nm)
- ENDPT 2: AZRAN of the eastern-most point (nm)
- MIN (inbound) velocity, ALTitude (ARL in kft), AZ/R (AZRAN in degrees and nm)
- MAX (outbound) velocity, ALTitude (ARL in kft), AZ/R (AZRAN in degrees and nm)

VCS Limitations

1. ***Doppler velocities are relative to the RDA.*** As stressed in Velocity Interpretation, you must always know where the phenomenon is in relation to the RDA. This increases the importance of baseline map in the upper right of the cross section.
2. ***Height exaggerated versus range*** (70,000 ft vs. up to 124 nm range). This is the same limitation observed in the RCS product. Features are not to scale, and appear thinner and taller than they actually are.

3. ***Interpolation may enlarge or miss features.*** Just as with the RCS product, gaps in the VCP will result in interpolations which may smooth out or enlarge a particular feature (especially in VCP 21).

4. ***Storm Relative cross section is NOT available. This may make it difficult to interpret signatures in especially fast moving storms.***

5. ***Storm top divergence estimates are limited due to radar viewing angle and data thresholds.*** Difficult to determine hail larger than golf ball size using NSSL criteria unless both maxima listed on the top of the grid are close to the the storm summit.

* Remember, a VCS perpendicular to the radial can be used to see rotation, while a VCS along a radial can be used to see convergence/divergence. However, the ability to see features with the cross section products is highly dependent upon placement of the cross section. A 4-panel velocity or SRM (or use all of the tilts) will probably get better results.

VCS Applications (Strengths)

1. **Aid in determining storm structure features** such as:
   - Inferring location of updrafts/downdrafts
   - Strength of storm top divergence
   - Depth of mesocyclones
2. **Has proven very valuable for kinematic insights in a research setting.**

Interim Summary

8-bit SRM

1. Generated by AWIPS using the 8-bit Base Velocity at AWIPS.
2. The user can set the storm motion to either the last motion used by WarnGen, the average motion of all storms from Storm Track algorithm, or that directly input by the operator.
3. Provides higher spatial resolution (0.13 nm vs. 0.54 nm) and greater number of data levels (256 vs. 16) than the 4-bit SRM product.
4. Aid in determining shear regions and storm top divergence which may be obscured by storm motion.
5. Especially useful with faster moving storms.

4-bit SRM

1. Storm motion subtracted from Base Velocity data at the RPG.
2. Storm motion defaults to average motion of all storms from Storm Track algorithm, but operator may input motion.

Velocity Cross Section

1. Vertical cross section of the Base Velocity data.
2. Should be generated either along a radial to see convergent or divergent signatures, or over short distances perpendicular to a radial to see rotation.
3. Aid in inferring updraft/downdraft interface locations, storm top divergence and the depth of mesocyclones.

Velocity Azimuth Display (VAD)

VAD Overview

Although the VAD product is not a commonly used product, the VAD winds are output to two important places -- the VAD Wind Profile (VWP) Product and the Environmental Winds Table. Therefore, an understanding of the VAD Algorithm and VAD product is important.

You have used the Base Velocity products and attempted to infer wind speed and direction at a particular height (range) by using the zero isodop. The VAD algorithm attempts to do this at several heights. The VAD Product is a scattering of data points used to compute the wind speed and direction for a given height. Although only radial velocity (inbound or outbound) is measured at a given point, the radial velocities 360 degrees around the radar at a given height (range) can produce an estimate of the average wind speed, and actual wind direction (i.e., the azimuth of the strongest inbound wind approximates the direction the wind is coming from).

Algorithm Methodology

Slant Range

1. The VAD winds are computed using a single elevation angle at a constant ***slant range***. For each altitude requested on the VAD Wind Profile, the VAD Algorithm selects the elevation angle that is closest to intersecting that altitude at the ***VAD range*** (adaptable parameter with a default of 30 km or 16.2 nm). The actual slant range will change dependent upon the altitude for which the VAD wind is being calculated. (See Fig. 5-68 on page 5-121.)

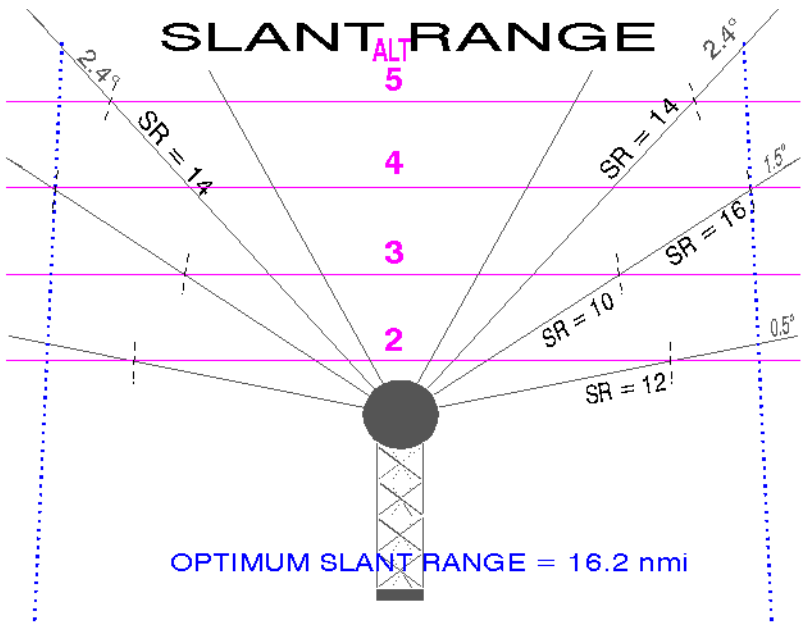


Figure 5-68. Slant Range

Velocity Data Plotted

2. ***A 0.13 nm resolution base velocity data point is plotted on a graph at each azimuth.*** The x-axis on the graph is azimuth (0°/360° for N, 180° for S of the RDA), and the z-axis is velocity (positive outbound velocities at the top and negative inbound velocities at the bottom).

Sine Wave Fit to the Data

3. If there are ***25 data points*** plotted on the graph, the algorithm then computes a ***sine wave*** to fit to the data using least squares fit method (see Fig. 5-65 on page 5-110). The VAD wind is computed from this sine wave. The amplitude of the sine wave is the estimated wind speed. The strongest inbound portion of the sine wave (closest to the bottom of the graph) becomes the estimated wind direction.

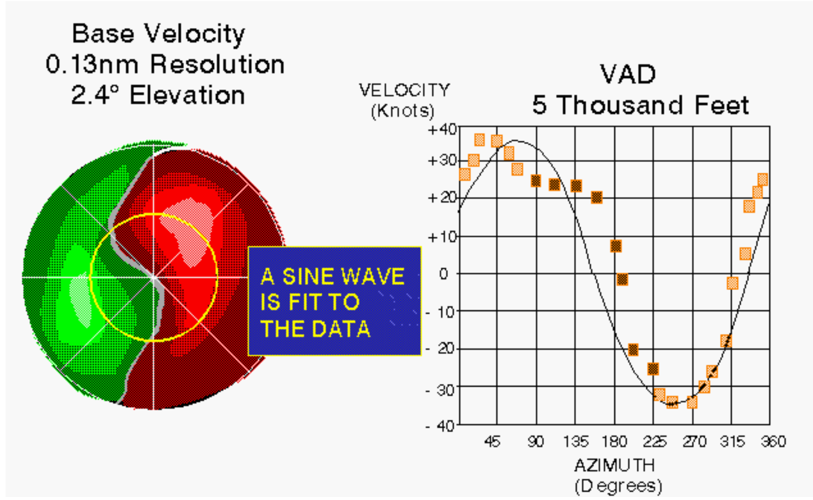


Figure 5-69. VAD data fit.

Symmetry and RMS error

4. Two additional values are calculated -- ***Symmetry and RMS error. Symmetry*** is the difference in knots between the zero velocity line on the VAD coordinate system and the median line of the sine wave curve. If the symmetry is negative (median line below the zero line) the inbound winds are stronger than the outbound indicating convergent flow at the radar site. Positive symmetry indicates diverging wind. ***RMS error*** (Root Mean Square error) is a calculation of the variation of the winds from the plotted sine wave. ***RMS error can be used as an indicator of the reliability of the wind estimate.***

If the symmetry exceeds 13.6 kts, or the RMS error exceeds 9.7 kts (ROC adaptable parameters), the winds can be determined by the operator using the plotted sine wave, but will not be output to the VAD Wind Profile (VWP) product.

VAD Altitudes

The VAD is available only for heights requested on VAD Wind Profile (VWP). These heights are determined by the user at the VAD and RCM Height Selection screen ***at the RPG HCI*** (URC adaptable). See Fig. 5-70 on page 5-123.

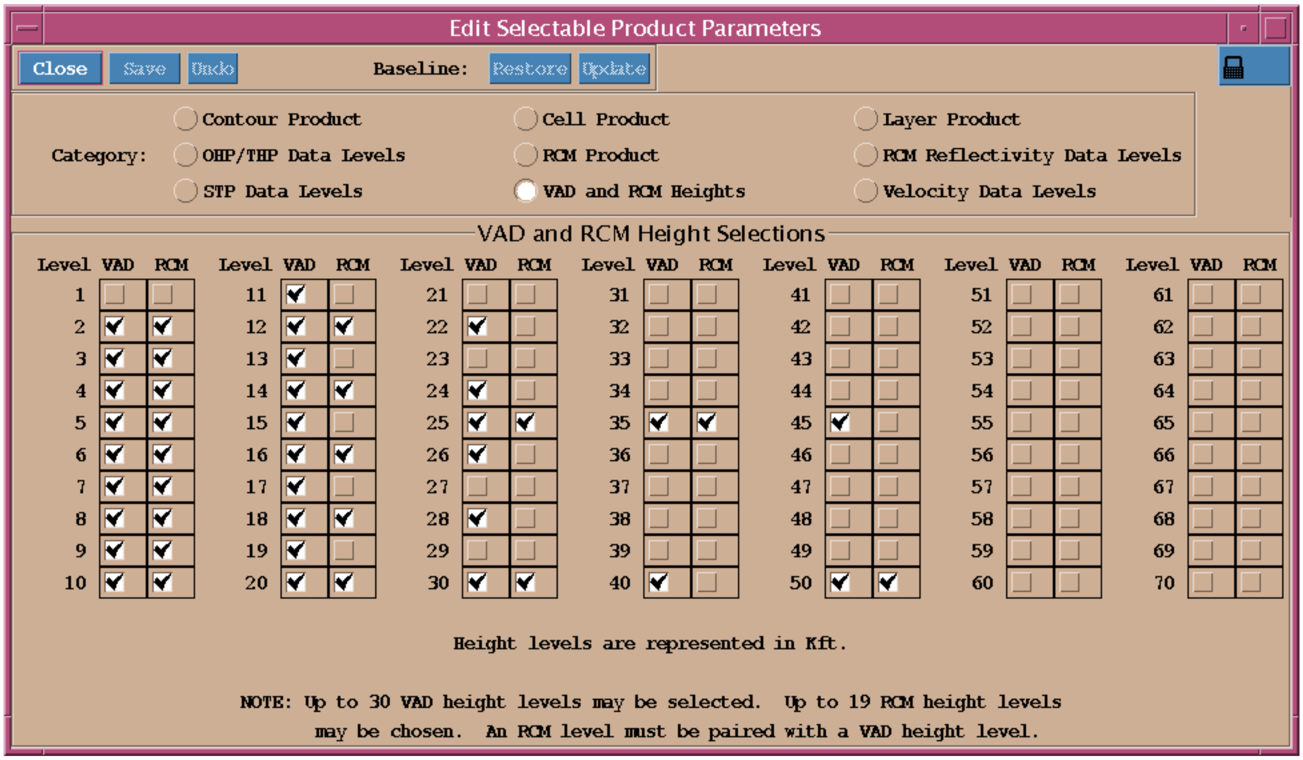


Figure 5-70. VAD Height Selection screen at the RPG HCI.

VAD Adaptable Parameters

There are three VAD adaptable parameters of importance: range, beginning azimuth and ending azimuth. They are edited at ***the RPG HCI*** (Fig. 5-71).

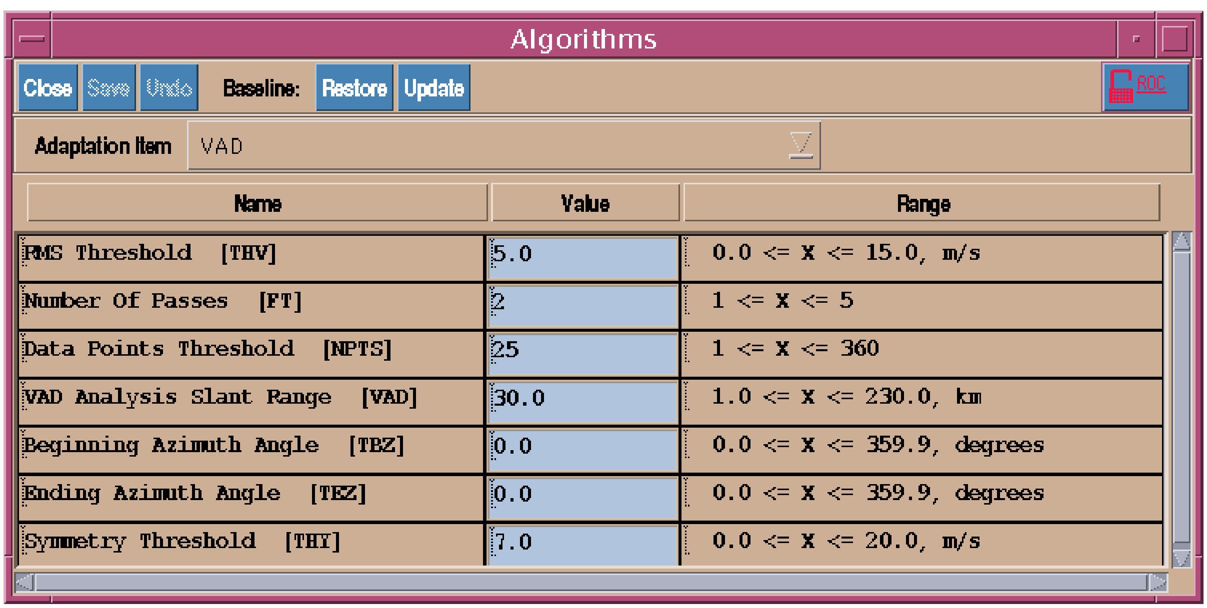


Figure 5-71. VAD Adaptable Parameters edit screen at the RPG HCI.

Output to the Environmental Winds Table

VAD winds are also output to the Environmental Winds Table used in the Velocity Dealiasing Algorithm. If the VAD winds are bad, the RPG HCI operator can turn off Auto Update, and manually input winds from a raob or profiler (Fig. 5-72).

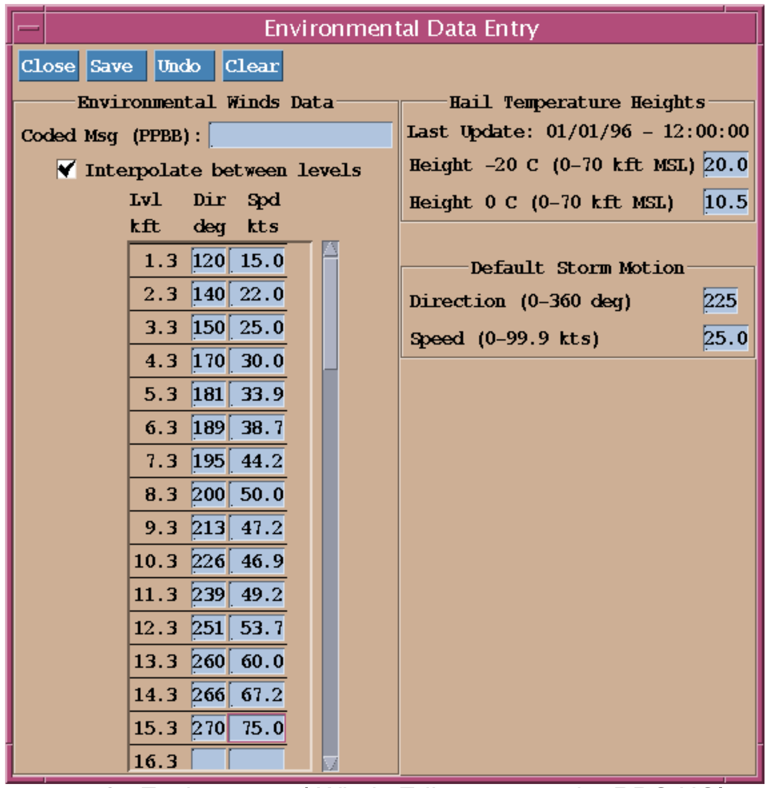


Figure 5-72. Environmental Winds Edit screen at the RPG HCI.

The VAD can be put on the RPS list or is available as a one-time request. The parameter that must be selected is the height in kft. See Fig. 5-73 on page 5-125.

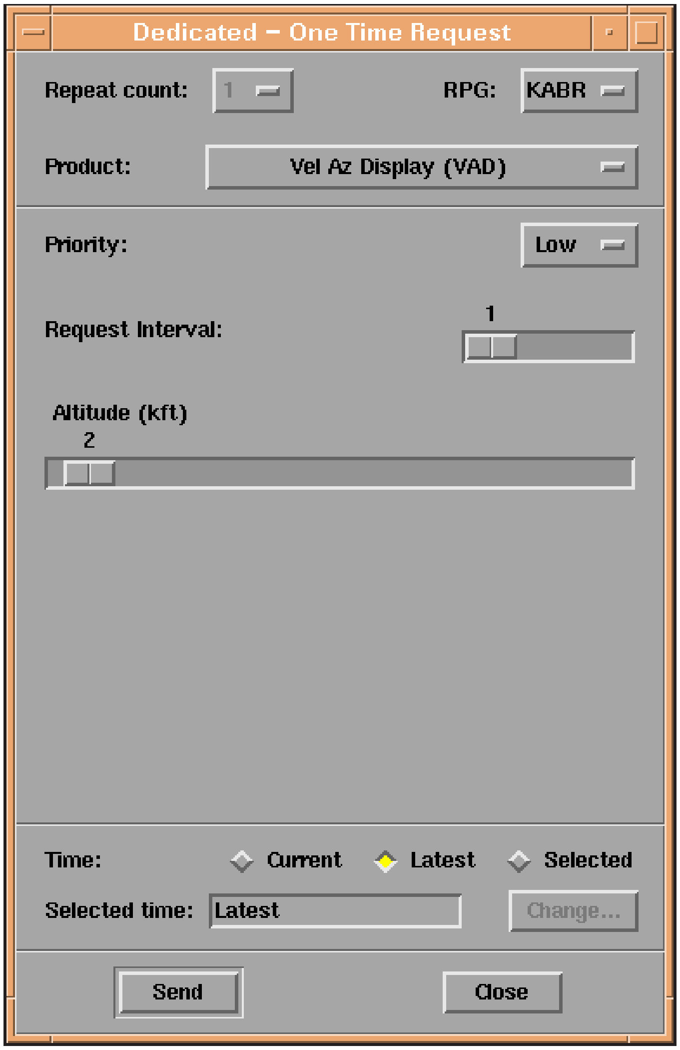


Figure 5-73. VAD product request screen.

VAD Product Parameters

See Fig. 5-74 on page 5-126 for an example of the VAD product

VAD product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Velocity Azimuth Disp
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

VAD Product Annotations

- VCP: 11, 12, 21, 121, 31 or 32

- ALT: Height in kft
- ELEV: Elevation angle that intersects selected height at the VAD range
- RNG: VAD Range
- WND: Wind direction and speed
- RMS: Root Mean Square error

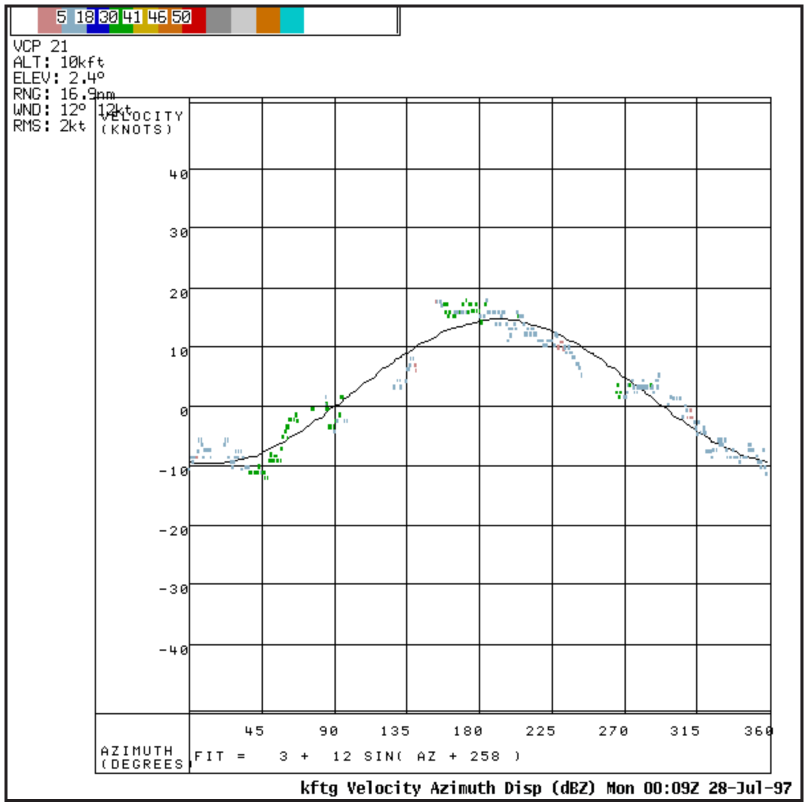


Figure 5-74. Velocity Azimuth Display (VAD) product.

VAD Limitations

1. ***Needs sufficient data points*** - Clear, cold, dry air often lacks scatterers. No sine wave will be plotted unless there are at least 25 data points.
2. ***May be unreliable in disturbed environments*** - The algorithm assumes horizontal uniformity of the wind field. If there is a front or boundary near the RDA, the data will often fail either RMS or symmetry thresholds.

3. ***Available for preestablished altitudes only*** - As designated at the RPG HCI for the VAD Wind Profile.

4. ***Large flocks of migrating birds may produce anomalous wind data.*** The averaging of the motion of birds in conjunction with the motion of the wind, can lead to erroneous wind data. Birds can cause the speed to be off by several knots and the direction to be off by several degrees. Typical symptoms include an "explosion of reflectivity returns in a "butterfly" pattern centered on the RDA just after sunset.

VAD Applications (Strengths)

1. ***VAD Winds are available in clear air or precipitation mode***. Generally speaking, the wind estimates will be slightly better in clear air mode since the radar antenna rotation is slower.

2. ***The VAD algorithm does not require 360 degrees of data.*** The algorithm only requires 25 data points (a sample from 25 degrees of azimuth), and they don't have to be contiguous. It is possible to only sample a certain sector to produce the VAD winds. For example you could decide to only sample the area between 135° and 225° to get an estimate of the winds ahead of the front. The "Beginning" and "Ending" azimuth is set at the RPG HCI (under URC Control).

3. ***Check missing or suspicious wind data on the VAD Wind Profile (VWP)*** - This is probably the primary reason many operators choose to look at the VAD Product. When you see "ND" plotted on the VAD Wind Profile, you can request the VAD at that altitude and see what happened: no sine wave could be plotted due to high RMS error (>9.7 kts), convergence or divergence in the wind flow produced a symmetry error exceeding limits (>13.6 kts), or too few data points (<25).

4. ***Update Environmental Winds Table. The VAD winds are fed into the Environmental Winds Table for use in the velocity dealiasing algorithm. This helps minimize dealiasing errors.***

VAD Wind Profile (VWP)

For example see Figure 5-75 on page 5-130.

VWP Overview

The VAD Wind Profile Product (VWP) is a vertical profile of VAD-derived winds at various levels. Winds are plotted on a grid with the X-axis as time and the Z-axis as height in thousands of feet. As many as 11 profiles (11 volume scans) are plotted with the most recent profile at the far right side of the grid (opposite of the Wind Profiler Network time-height profiles).

Product Characteristics

The VAD Wind Profile (VWP) Product has the following characteristics:

- **Altitudes:** A maximum of 30 altitudes can be displayed each volume scan. The displayed MSL altitudes are selected at the RPG HCI. There must be a minimum of 1000 feet between levels. The lowest level selected should be the first altitude above the radar level (i.e., if the radar is at 2212 feet, then the lowest altitude selected should be 3 thousand feet). Altitudes to 70,000 feet can be selected, but winds above 45,000 feet are uncommon.
- **Wind Barbs:** Winds are displayed in the standard convention with the shaft always being the same length:
  - Small open circle - < 4 kts
  - 1/2 barb - 4-7 kts
  - full barb - 8-12 kts
  - flag triangle - 50 kts

- **Data Levels** - The data levels of the VWP represent the RMS error in kts of the VAD winds. Recall that the RMS error is a measure of how well the sampled data points fit the sine curve. The first data level represent RMS errors less than 4 kts, the second data level 4-7 kts, and the third data level 8-11 kts. Higher data levels will not be seen on the VWP since **"ND"** will be displayed if the RMS error exceeds 9.7 kts.
- **ND** - No Data will appear if:
  - there are fewer than 25 data points
  - RMS error greater than 9.7 kts, or
  - symmetry is greater than 13.6 kts

VWP Product Parameters

See Fig. 5-75 on page 5-130 for an example of the VWP product

VWP product legend description:

- RPG ID: kxxx
- PRODUCT NAME: VAD Wind Profile
- UNITS: RMS kts
- DATE: Day of week, time, and date in UTC

VWP product annotations

- VCP: 11, 12, 21, 121, 31 or 32
- HT(MX): Height of the maximum wind from the most recent volume scan.
- MXWND: Maximum wind direction and speed from the most recent volume scan.

VWP Adaptation Data

The VWP Adaptation Data can be displayed at the AWIPS Text Display Window (WSRVWPxxx). This can be used to determine the adaptable parameter settings used to generate the product. See Fig. 5-76 on page 5-131.

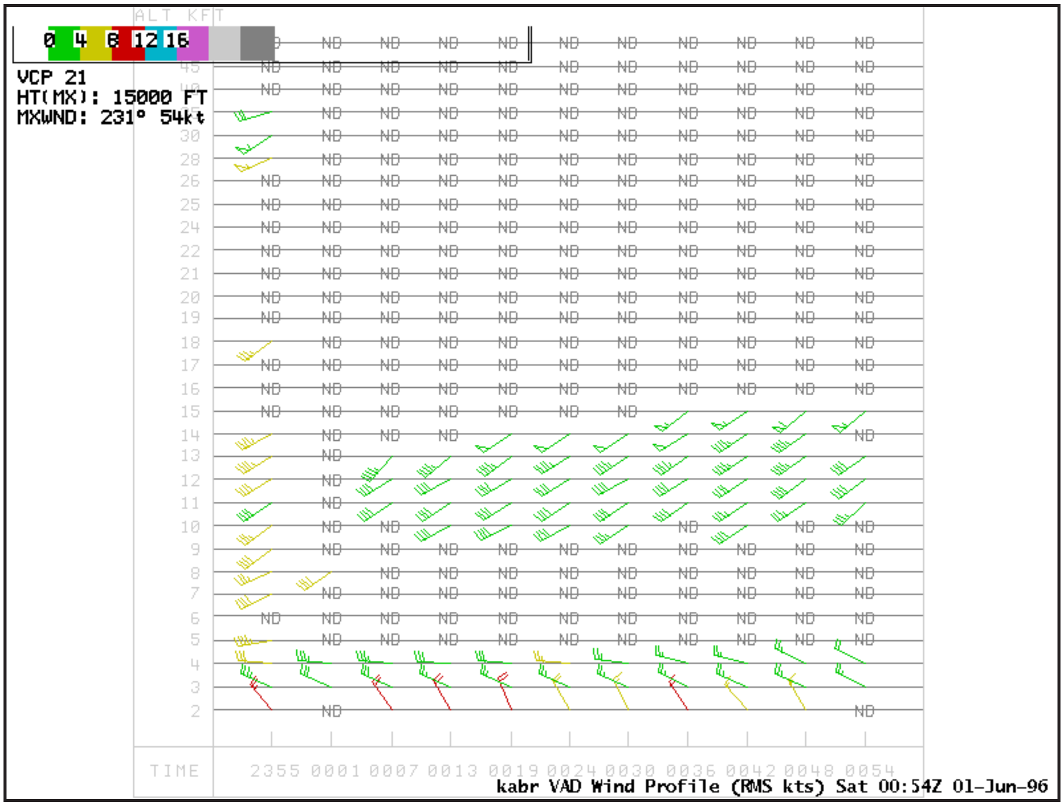


Figure 5-75. VAD Wind Profile (VWP) product.

VWP Hodograph

The VWP can be also be displayed as a hodograph in an AWIPS Interactive Skew-T using the following method.

1. Load WFO Scale and editable points (no need to load radar data).
2. Move a point to the RDA.
3. Open the Volume Browser and choose VWP as the source, sounding as the field, and the point corresponding to the one over the RDA.
4. Select Load.

VWP Limitations

1. ***Measurable returns needed -*** at least 25 data points are required on the individual VAD for data to be encoded at that altitude.
2. ***Winds are not encoded if RMS error or symmetry thresholds are exceeded.*** ND will

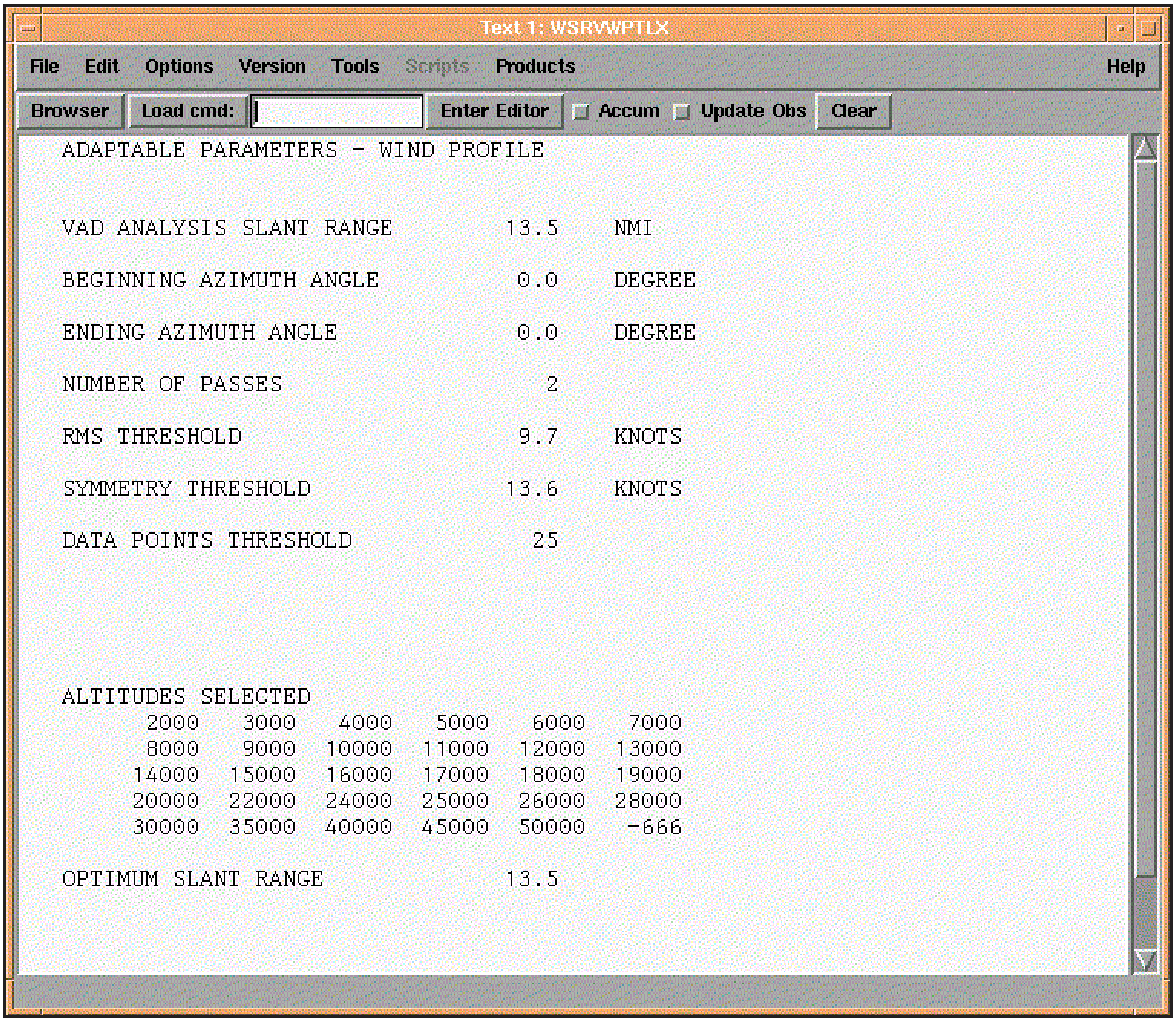


Figure 5-76. VWP adaptable parameters displayed at the AWIPS Text Display Window.

be plotted if RMS exceeds 9.7 kts or symmetry exceeds 13.6 kts.

3. ***Generally only representative of winds within 20 nm of the RDA.***

4. ***Difficult to read wind barbs when north wind barbs and south wind barbs are on successive altitudes.*** Use of the Filter or Blink Functions may help.

5. ***Birds can produce anomalous wind patterns.*** The usual scenario is an “explosion” of reflectivity coverage and strength as night migrating birds take off. Experts claim that a single Sea Gull can be detected at a range of 460 km. If it is critical to determine the true

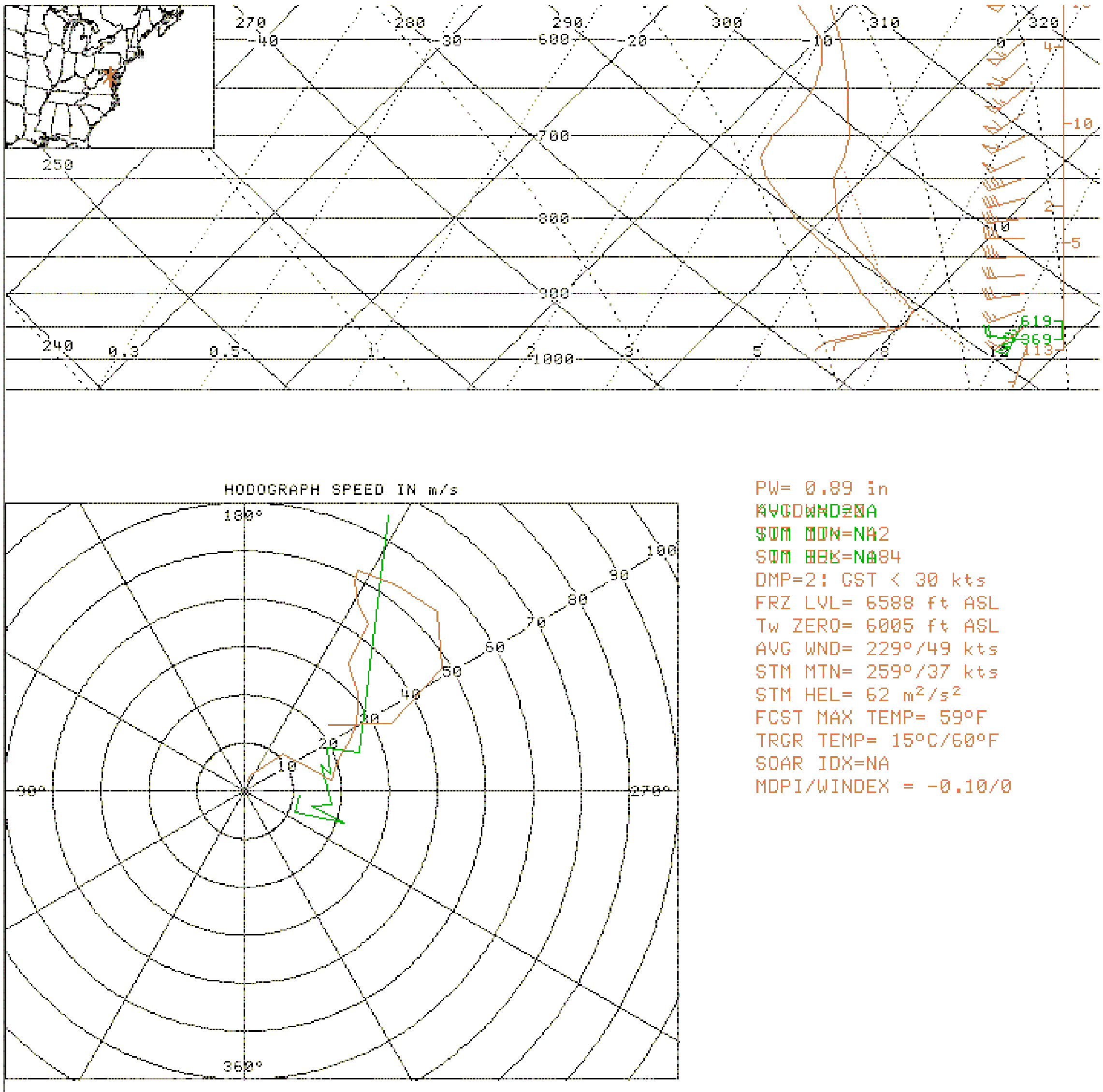


Figure 5-77. VWP hodograph (green) overlaid on Meso-Eta Hodograph (red).

upper winds, the site should take a supplemental balloon sounding.

VWP Applications (Strengths)

1. **The VAD Wind Profile (VWP) may be of assistance in many operations.** ***Severe Weather*** operations may benefit as backing or veering of the winds with time display changes in the environment. ***Aviation*** operations will be assisted by evidence of wind shear. Low level wind shear may be more visible on VWP than Profilers. ***Hydrology*** and ***Forecasting*** may benefit from indications of the change in the depth of cold air with time, etc. Since sufficient

scatterers are often more prevalent in and near clouds, the VWP may be used in estimating cloud tops and bases.

2. ***The VWP can be used to create/adjust hodographs(see Fig. 5-77 on page 5-132) .***
3. ***Future development may include combining the Storm Tracking Algorithm and VAD Wind Profile to output helicity***.

Interim Summary

Velocity Azimuth Display (VAD)

1. A scattering of data points and a fitted sine wave curve are used to compute the winds for individual heights.
2. Product used primarily to check wind data that is "suspect" or missing on the VAD Wind Profile.

VAD Wind Profile (VWP)

1. A composite vertical profile of VAD-derived winds at various levels.
2. Excellent tool for meteorologists in weather forecasting, severe weather, hydrology, and aviation.
3. If fewer than 25 data points exist, or the symmetry or RMS thresholds are exceeded, the VAD Wind Profile will display "ND" (no data) for that height.

Mesocyclone Detection

Review Of Operator Identified Mesocyclone

Modified NSSL Mesocyclone Definition

- - Small scale rotation closely associated with a convective updraft that meets or exceeds established thresholds for:
  - --Persistence - Minimum of two volume scans
  - --Vertical extent- Shear extends at least 10,000 ft in the vertical
  - ***--Shear*** (Fig. 5-78)
    - Distance between max inbound and max outbound ≤ 5 nm.
    - *Rotational velocity = velocity inbound + velocity outbound divided by* 2 (using mid-range values).

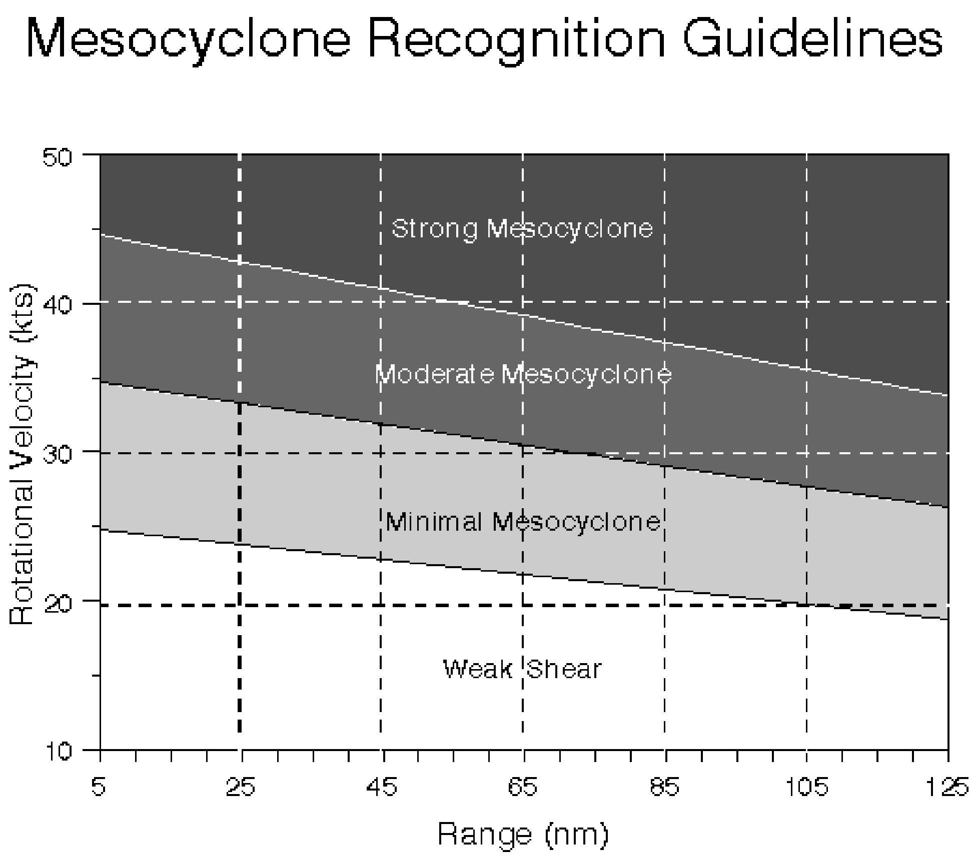


Figure 5-78. Assumes feature diameter of 3.5nm.

Mesocyclone Detection Algorithm (MDA)

Mesocyclone Detection Algorithm (MDA) detects a broad spectrum of circulations and includes tracking (past and future positions) of identified circulations. The MDA is one of the newest algorithms in the RPG and was implemented in two phases (RPG Build 5 - March 2004 and RPG Build 6 - September 2004). Output from the MDA has been also been phased in AWIPS. The MD product and DMD output in SCAN were implemented in AWIPS OB4 (September 2004). DMD output in AWIPS D2D was implemented in AWIPS OB5 (July 2005)

AWIPS Operational Build 5 (OB5) includes the Digital Mesocyclone Detection (DMD) product with a rapid update capability and an extensive attribute table. The DMD information is displayable in both D2D and SCAN (to be discussed further in the DLOC Workshop).

Legacy Mesocyclone Algorithm and Products

The legacy Mesocyclone algorithm products Mesocyclone (M- product ID 60) and Mesocyclone Rapid Update (MRU - product 139) are targeted to be removed from the RPG in WSR-88D Build 10 (November 2007). Until that time, attributes from the legacy Mesocyclone algorithm will continue to be used for:

- alerting (alert categories 9 and 26)
- combined attributes table of CZ product
- Radar Coded Message (RCM) product part C
- Central Data Collection
- archiving

In this section, we will only discuss products produced by MDA. For information on attributes from the legacy Mesocyclone algorithm including the Mesocyclone (M) and Mesocyclone Rapid Update

(MRU) products see the DLOC website: *http://wdtb.noaa.gov/courses/dloc/index.html*

MDA Products

With RPG Build 7 and AWIPS OB 5.0 two products are available from MDA:

- Mesocyclone Detection (MD)
  - end of volume scan
- Digital Mesocyclone Detection (DMD)
  - each elevation angle in table format

MDA Processing for a Single Elevation

For a particular elevation angle, MDA searches for shear segments and convergence vectors.

- A shear segment is a string of base velocity bins at a fixed range, where the values increase in a clockwise direction.
- A convergence vector is a string of base velocity bins at a fixed azimuth, where the values decrease in a direction away from the radar.

Minimum Reflectivity

Candidates for shear segments or convergence vectors must have corresponding reflectivity values above a threshold. This threshold is a URC adaptable parameter called the “Minimum Reflectivity”. The default setting is 0 dBZ (Fig. 5-79).

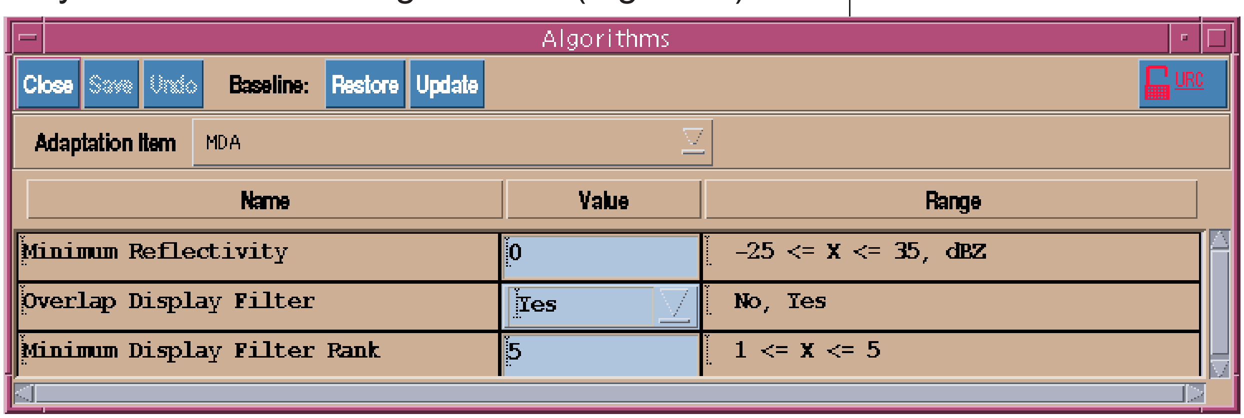


Figure 5-79. MDA Adaptable Parameters at the RPG HCI.

2D Shear Features

Shear segments from a single elevation are first combined into 2D features. The 2D feature creation is a complicated process, whereby numerous parameters are computed and saved for subsequent use.

Rotational velocity is calculated using the max inbound and outbound velocities in all shear segments (not necessarily from the same shear segment)(see Fig. 5-80) .

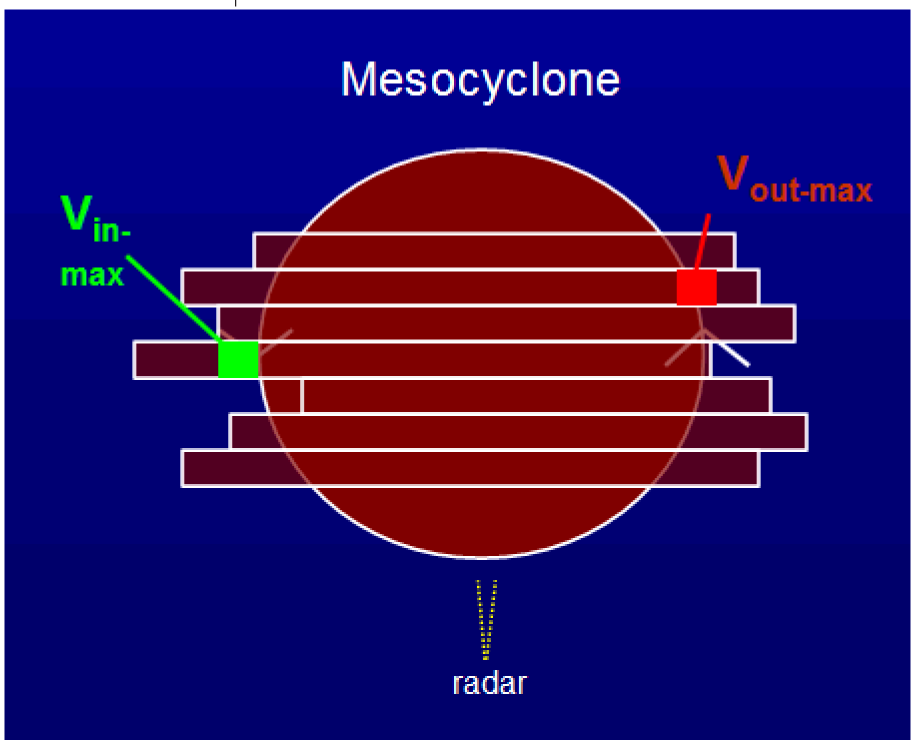


Figure 5-80. Shear segments combined into 2D Feature.

Once the 2D shear features are computed, the MDA also builds 1D convergence segments (peak inbound and outbound velocities along a single azimuth) that are used to compute average convergence within a 2 km buffer outside the mesocyclone base (see Fig. 5-81 on page 5-139). No

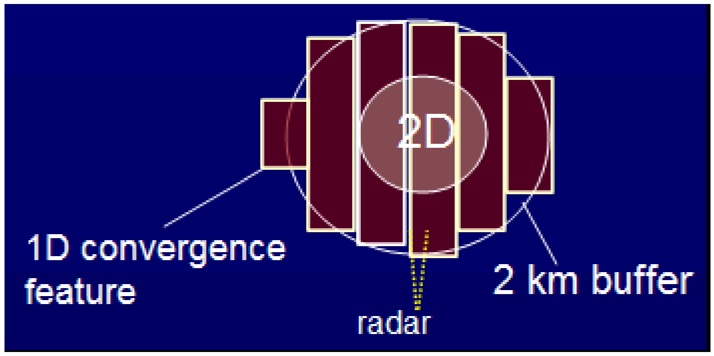
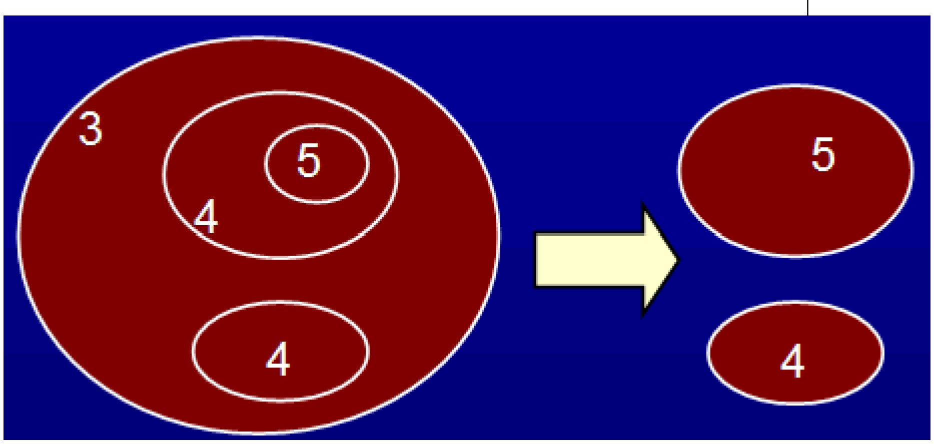


Figure 5-81. Convergence segments used to calculate convergence velocity differences.

divergence is calculated, only convergence velocity differences are calculated.

Unique cores of rotation are extracted from large areas of rotation to define the 2D features for a given radar tilt. Small features less than 1km (or less than 4 shear segments) are thrown away. In addition, non-circular features (such as shear along linear gust fronts) are thrown away if the aspect ratio of Dr/Da > 2 (see Fig. 5-82)



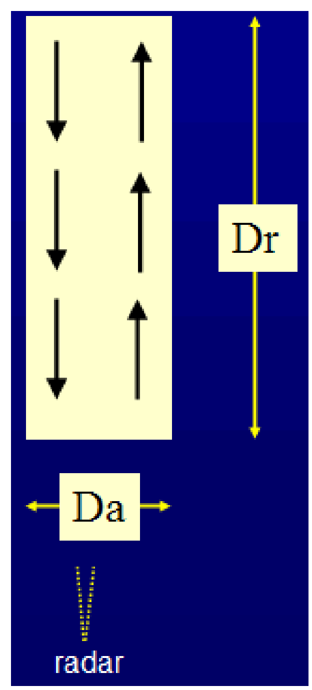


Figure 5-82. 2D Feature are sorted (above). 2D aspect ratio Dr/Da $\leq$ 2 (right).

MDA Processing for Multiple Elevation Angles

The 2D features are then vertically correlated and initially classified as "circulations". Each circulation is assigned an ID number, with numbers cycling from 0 to 999.

Strength Rank

One of the foundations of the MDA is the 3D strength rank. The 3D strength rank is a measure of the overall rotation through a certain depth of the storm(see Fig. 5-83) . The 3D feature depth, base, and strength are considered for three different classes of circulations:

- Low core (L),
- Shallow (S), and
- Traditional mesocyclone (default).

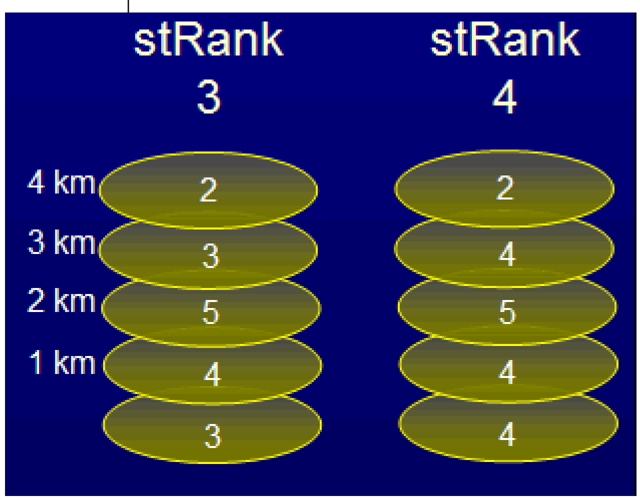


Figure 5-83. MDA defines a strength rank based on rotation through a certain depth.

Strength Ranks range from 1 as the weakest possible to 25 as the strongest. Any circulation with a Strength Rank of 5 or greater is classified as a Mesocyclone. The following thresholds are approximate out to 54 nm (100 km), with thresholds reduced from 54 to 108 nm (100 to 200 km):

- Strength Rank 3 ~ 20 kt Vr - Weak Shear

- Strength Rank 5 ~ 30 kt Vr - Minimal Meso
- Strength Rank 7 ~ 40 kt Vr - Moderate Meso
- Strength Rank 9 ~ 50 kt Vr - Strong Meso

MDA Adaptable Parameters

In addition to the Minimum Reflectivity, there are two other MDA adaptable parameters that are editable.

Minimum Display Filter Rank

The Minimum Display Filter Rank (Fig. 5-79 on page 5-137) identifies which circulations are displayed on the end of volume scan MD product. The default setting is 5, which means that all circulations with a Strength Rank of 5 or greater would be displayed on the MD product. If this parameter were set to 5 and the strongest circulation detected had a Strength Rank of 4, ***no*** circulations would be displayed. However, the DMD product would have an entry and will display all circulations, even those with ranks below the Minimum Display Filter Rank.

Overlap Display Filter

This parameter addresses the possibility of two circulations being displayed on a graphical product in the same location, i.e. the circles overlap. If the "Overlap Display Filter" parameter is set to the default value of **Yes** (see Fig. 5-79 on page 5-137), the 3D circulation that is detected over lower elevation angles is the one displayed.

Number of Detections vs. Weaker Circulations

Tornadoes are sometimes produced from small, weak circulations. The default setting of 5 for the Minimum Display Filter Rank is based on MDA performance with large, deep supercells. For environments where mini-supercells are favored, setting the Minimum Display Filter Rank to 3 or 4 is a consideration. The smaller circulations will be displayed on the MD product. However, the total number of circulations displayed will increase significantly as the value of this parameter is lowered.

Tracking Features

MDA has a process that attempts to track 3D circulations from one volume scan to the next. At the end of a volume scan, all 3D features are assigned an extrapolated position for the subsequent volume scan based on previous positions. The locations projected from the previous volume scan are then used to try to match to 3D features detected from the current volume scan.

If There is a Match

If a 3D feature is matched for more than one volume scan, the past positions and forecast positions will be displayed. This is very similar to the past and forecast positions for a storm centroid generated by the SCIT algorithm. Past and forecast tracks computed by MDA apply to the 3D feature. Circulations are tracked for up to 10 previous volume scans and up to six forecast positions are computed in 5 minute intervals. The number of forecast positions will never exceed the number of past positions.

Once matched, 3D features will appear on both the MD and DMD products.

If There isn't a Match

A 3D feature from a previous volume scan is retained until there is a match to the subsequent volume scan. However, the search to obtain a match does not persist for the entire volume scan. For a 3D feature detected from a previous volume scan, the search persists until the height of the radar beam is 3 km above the base of the feature. Once the radar beam reaches that height, the feature is removed.

Unmatched features will not be shown on the MD product. They may appear on some elevations of the DMD output while the search for a match is ongoing.

Mesocyclone Detection (MD) Product

The Mesocyclone Detection (MD) product is available at the end of the volume scan. The MD is displayable from the graphics menu (see Fig. 5-84). Also on this menu are two entries for the Legacy Mesocyclone and Meso Rapid Update (MRU). The MRU product is based on the ***legacy*** Mesocyclone algorithm information and will not be discussed in this section. The elevation by elevation output from the Mesocyclone Detection Algorithm (MDA) is displayed on the Digital Mesocyclone Detection (DMD) product and in the System for Convection Analysis and Nowcasting (SCAN) discussed at the DLOC workshop.

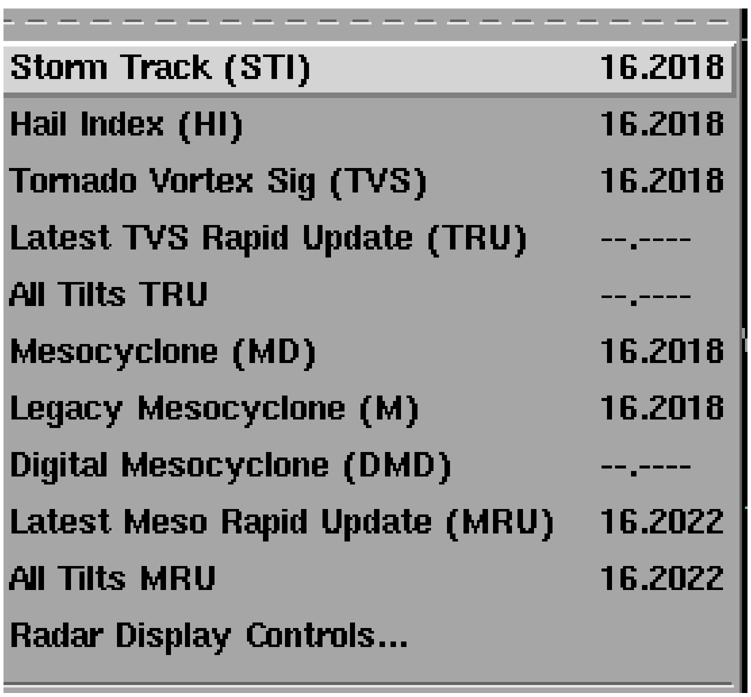


Figure 5-84. Graphics window with entries to display the MD, DMD, and legacy M and MRU products.

If the MDA adaptable parameters are set to their default values (see Fig. 5-79 on page 5-137), the MD product will be similar to the legacy Mesocyclone product ***with respect to which circulations***

are displayed, although there is more information displayed about the circulation on the MD product.

One significant difference is the inclusion of past and forecast tracks provided by the MD product, as long as there are matches from one volume scan to the next.

MD Symbols

There are two symbols (or icons) on the MD product -- a thin yellow circle is used for circulations with a strength rank of 1 through 4, and a thick yellow circle is for circulations with a strength rank of 5 or above. However, if the Minimum Display Filter Rank is set to the default value of 5, thin circles will ***not*** be seen.

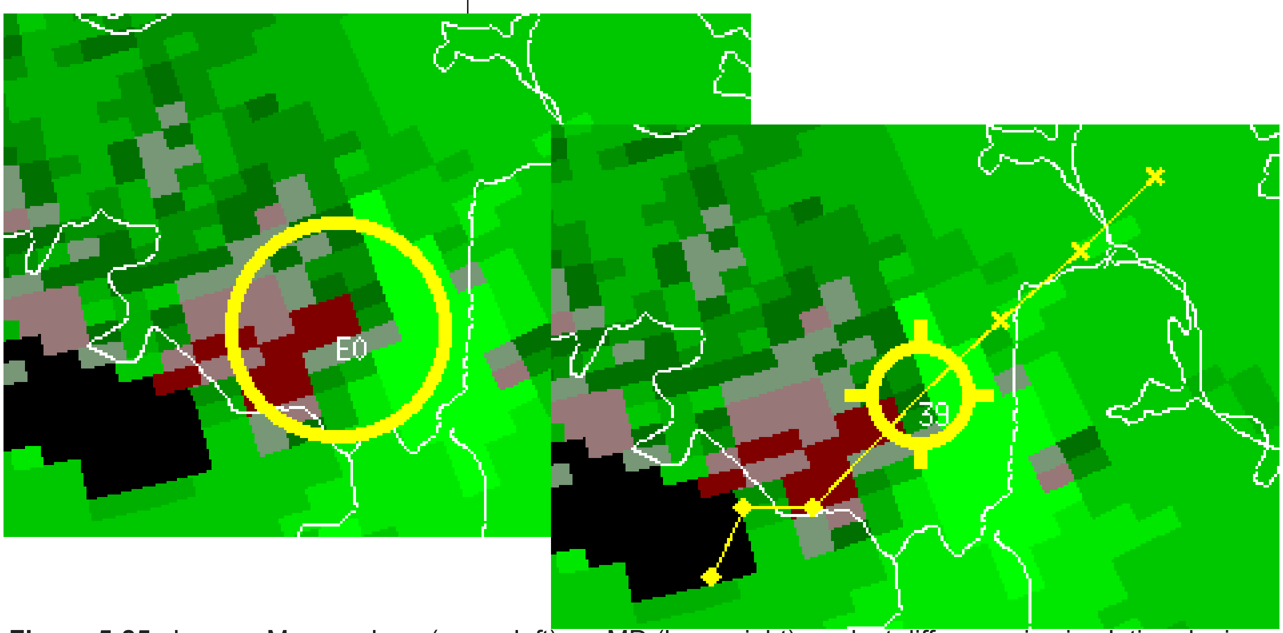


Figure 5-85. Legacy Mesocyclone (upper left) vs. MD (lower right) product difference in circulation depiction.

Assuming the same default setting of 5, if a circulation with a strength rank of 5 or above is detected on the lowest elevation angle (or a base is detected at or below 1 km), four spikes are added to the yellow circle. In Figure 5-85, a low level circulation is depicted on the Legacy Meso product (upper left) and on the MD product (lower right). MDA assigns a 3 digit identification number to each circulation, ranging from 0 to 999. InFigure 5-85 the circulation ID for the MD product (lower right) is 39.

The MD product also has an attribute table at the top of the graphical product (see Fig. 5-86), and a text version.

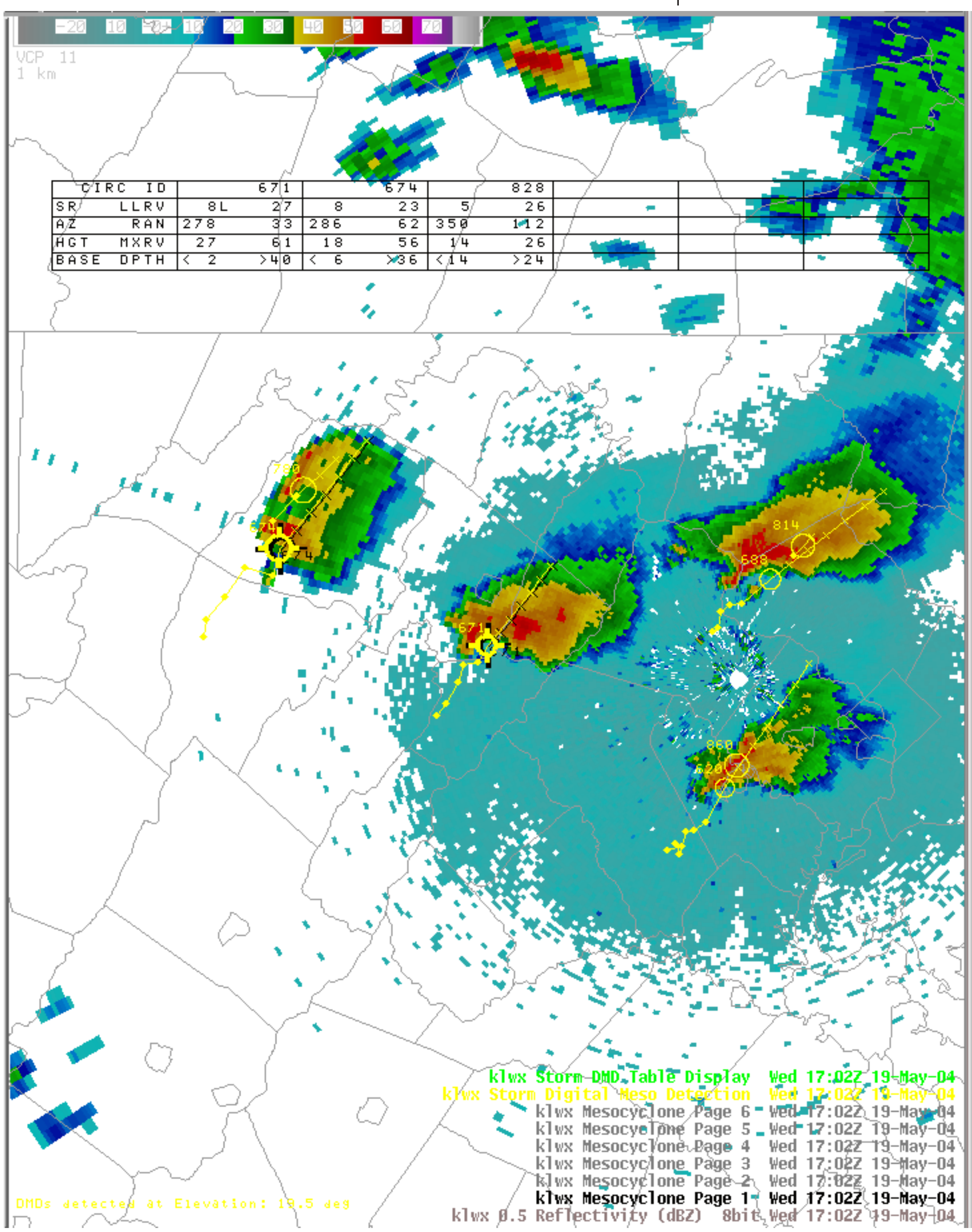


Figure 5-86. MD product overlaid on base reflectivity.

MD Limitations and Applications (Strengths)

The characteristics of the MD product and DMD product are different, but they are produced by the same algorithm and therefore share similar limitations and strengths/applications. See the limitations and strengths/applications of the MD product listed at the end of the next section on the DMD product.

Digital Mesocyclone Detection (DMD) Product

The Digital Mesocyclone Detection (DMD) Product is displayed from the “kxxx” radar menu under the graphics submenu (see Fig. 5-84 on page 5-143). Data from the MDA is also displayable in SCAN and in the form of time-height diagrams in the volume browser. Both the SCAN and volume browser displays will not be discussed in this section, but will be discussed in the DLOC workshop.

DMD Symbols

DMD uses dynamic progessive disclosure of features, with weaker features shown as the product is zoomed. The thicker circles show higher strength rank. The 4 spikes indicate the circulation extends to the lowest elevation angle, and the dashed appearance indicates an extrapolated position (see Fig. 5-87 on page 5-147) .

DMD Extrapolated Positions

DMD is updated each elevation slice. Extrapolated positions are the expected positions of circulations identified on the previous volume scan. These are identified as extrapolated until a match with a circulation on the current volume scan is made.

DMD Cursor Readout

One feature of the DMD product is the cursor readout. As you move the cursor over the circulation you will see several of the attributes of that feature. The cursor readout can include various attributes including radar id, circulation id, closest storm ID, strength rank, speed/direction of movement, base, depth, etc.(see Fig. 5-88 on page 5-148)

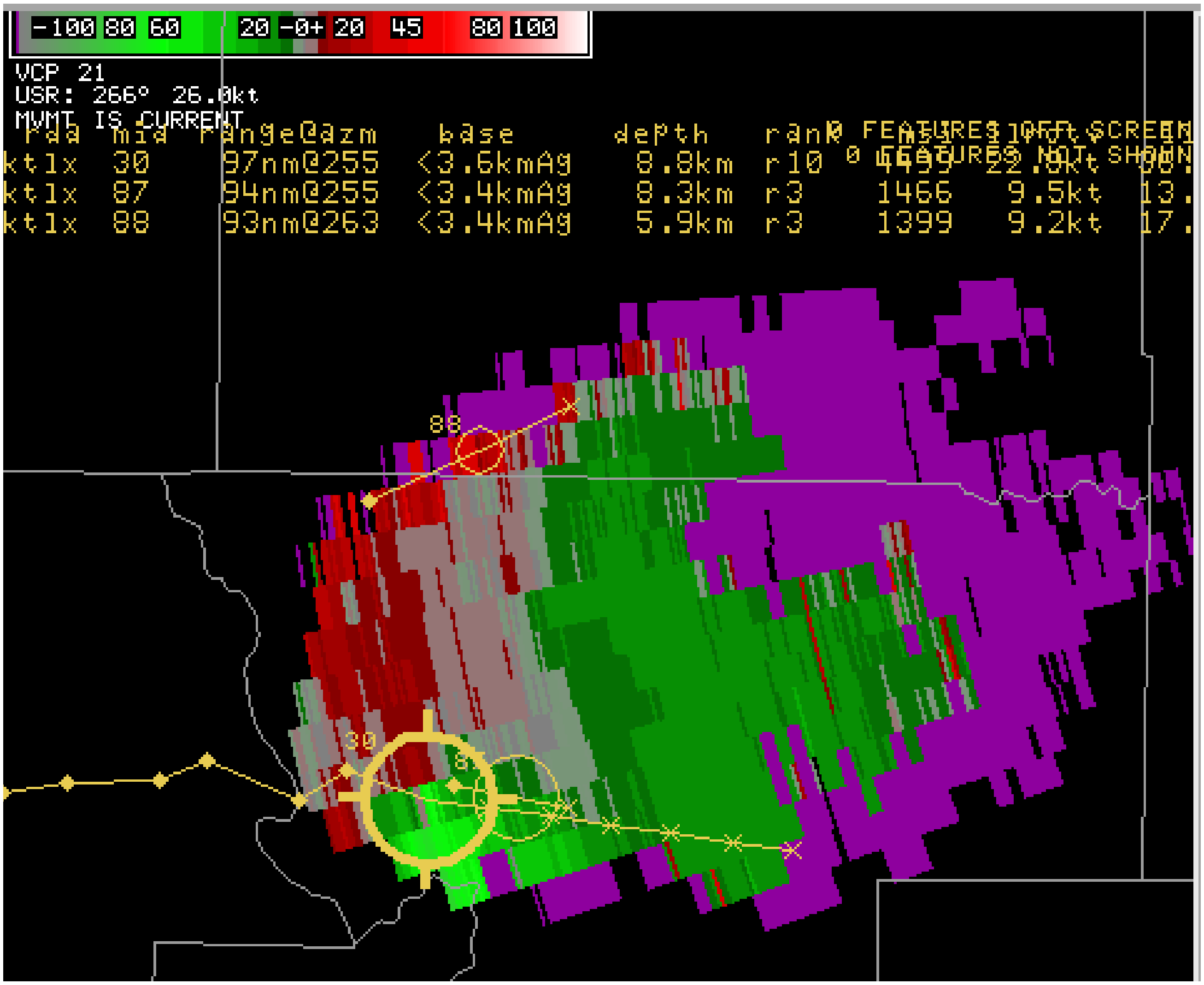


Figure 5-87. This DMD example is overlaid on an 8-bit SRM product. It is zoomed to show the weaker circulations (circulations 87 and 88).

MD and DMD Limitations

1. **Does not need 10,000 ft deep circulation.** The algorithm only requires vertically linked 2D circulations.
2. ***The algorithm only detects cyclonic rotations.***
3. **Identification is influenced by aspect ratio.**
4. **Improper dealiasing may generate false mesocyclones.**
5. **Default settings are for large deep supercells.** Changes to adaptable parameters are required for smaller circulations.

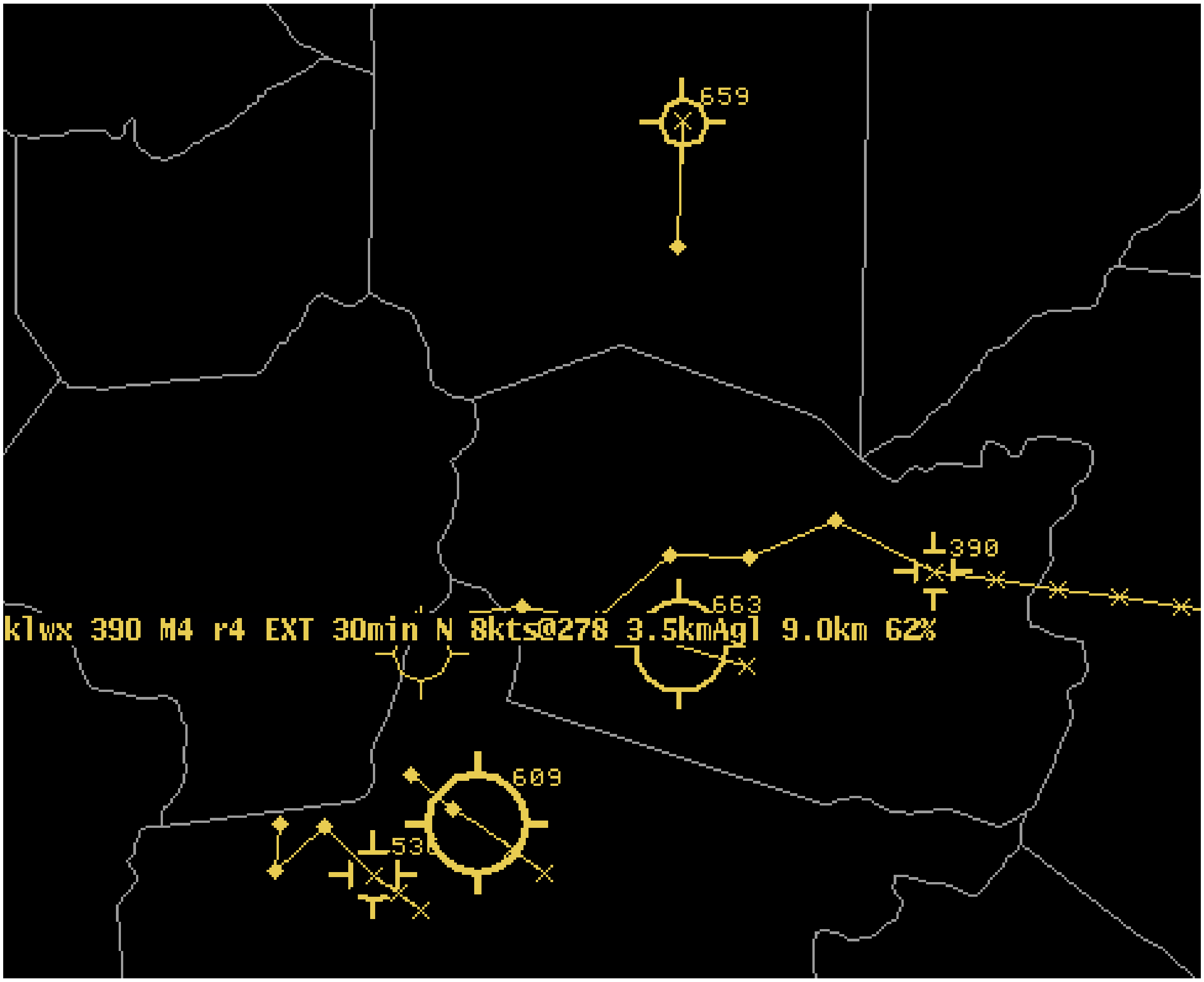


Figure 5-88. This DMD example displays the cursor readout as the cursor was over circulation 390 at the far right of the graphic.

6. **Numerous detections of circulations may require changes in adaptable parameters.**

MD and DMD Applications (Strengths)

1. **Identify mesocyclones** - The operator must examine reflectivity, velocity, and SRM to verify existence of mesocyclones.
2. **Weak circulations detected.**
3. **Adaptable parameter changes available to adjust the output to fit the meteorological situation.**
4. **Tracking attempts to account for time continuity.**

Tornadic Vortex Signature (TVS)

Review of Operator Identified TVS

Modified NSSL TVS Definition

An intense gate-to-gate azimuthal shear associated with tornadic-scale rotation. A TVS is identified if the gate-to-gate shear is:

$\geq$ 90 kts and the range is $<$ 30 nm

$\geq$ 70 kts and the range is 30 nm $\leq$ r $<$ 55 nm

Gate-to Gate Shear = Velocity Difference = | velocity inbound | + | velocity outbound |

Remember that these values are only guidelines, the user will have to adjust according to the situation and geographic location.

Tornado Detection Algorithm (TDA)

The Tornado Detection Algorithm (TDA) is designed to detect significant shear regions in the atmosphere. The TDA uses multiple velocity thresholds to locate shear regions, and classifies these regions according to altitude and strength.

The Mesocyclone and Tornado Detection algorithms process data separately. This means that ***an algorithm-identified mesocyclone need not exist for a TVS or Elevated TVS (ETVS) to be identified.*** The TDA is modeled after the SCIT algorithm and uses a three step process to identify circulations.

TDA Process

First, 1-D pattern vectors are identified on each elevation slice. In TDA, a pattern vector is a region of gate-to-gate shear, which means the velocity difference is calculated between range bins

located on adjacent azimuths at the same range. A minimum shear value is required for a pattern vector to be identified (see Fig. 5-89 on page 5-150) . The TDA searches only for patterns of velocity indicating cyclonic rotation. It ***does not*** detect an anticyclonic signatures.

Range	rad #1	rad #2	rad #3	rad #4	rad #5	rad #6	rad #7
33.00 km	-7	-10	-10	-7	1	2	1
32.75 km	-10	-15	-13	-11	4	3	0
32.50 km	-4	-11	-14	-18	12	22	13
32.25 km	-11	-19	-22	13	18	11	-1
32.00 km	-4	-9	-19	3	13	17	12
31.75 km	-10	-14	-22	1	21	9	9
31.50 km	-10	-25	-19	-6	4	2	1
31.25 km	-7	-3	-5	-6	4	13	10
31.00 km	-1	2	1	-3	-4	-4	-6

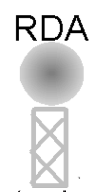


Figure 5-89. All increasing velocities (cyclonic shear) are shaded blue. All TDA Pattern Vectors (>11 m/s shear) are shaded pink.

Range	rad #1	rad #2	rad #3	rad #4	rad #5	rad #6	rad #7
33.00 km	-7	-10	-10	-7	1	2	1
32.75 km	-10	-15	-13	-11	4	3	0
32.50 km	-4	-11	-14	-18	12	22	13
32.25 km	-11	-19	-22	13	18	11	-1
32.00 km	-4	-9	-19	3	13	17	12
31.75 km	-10	-14	-22	1	21	9	9
31.50 km	-10	-25	-19	-6	4	2	1
31.25 km	-7	-3	-5	-6	4	13	10
31.00 km	-1	2	1	-3	-4	-4	-6

Not Included

Figure 5-90. 2-D Feature outlined in yellow.

Next, 2-D features are created by combining the 1-D pattern vectors (see Fig. 5-90 on page 5-150). At least three pattern vectors (default) are needed to declare a 2-D feature.

TDA uses six velocity difference thresholds to identify pattern vectors. This technique allows the algorithm to isolate core circulations which may be embedded within regions of long azimuthal shear. An example would be a radially oriented gust front or squall line. In Figure 5-91, a long segment of shear exceeding 15 m/s has embedded within it a smaller segment of shear greater than 20 m/s, and still smaller segments of shear greater than 25 m/s. If a 2-D feature passes a symmetry test (length to width ratio within a specified limit), it is declared a 2-D circulation.

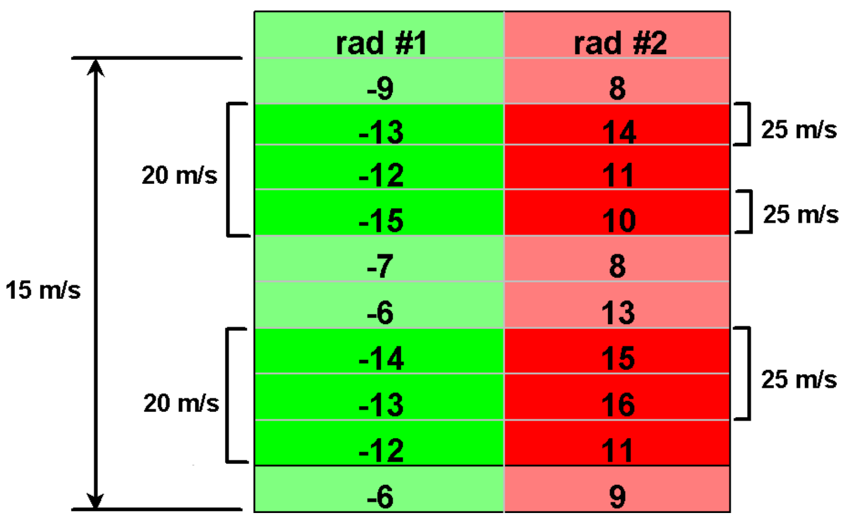


Figure 5-91. 2-D Features - Multiple velocity thresholds used to identify stronger shear embedded within weaker shear.

Finally, 3-D features are created by vertically correlating the 2-D circulations identified at each elevation (see Fig. 5-92 on page 5-152). Processing begins by correlating the strongest 2-D circulations first, then moving to progressively weaker circulations. If a feature contains at least three vertically correlated 2-D circulations, it is declared a 3-D circulation, and identified as either a TVS or an ETVS. Ideally, there will be no gaps in elevation angles between the vertically correlated 2-D circulations. However, a one elevation angle gap is permitted to account for base data problems such as range folding and velocity dealiasing failures.

TDA Adaptable Parameters

There are a number of TDA adaptable parameters. Six of these parameters ar under URC Level of Change Authority. A more in-depth look at these adaptable parameters is available in the RPG Adaptable Parameters Handbook Section 6.15 (http://www.roc.noaa.gov/ssb/sysdoc/manuals/Operations_TMS/AporpgSCR1.pdf).

Three of the adaptable parameters are changed as a set (default value in parenthesis):

- Minimum 3D Feature Depth (1.5 km)
- Minimum Low Level Delta Velocity (25 m/s)
- Minimum TVS Delta Velocity (36 m/s)

The other three can be set independently based on URC preference:

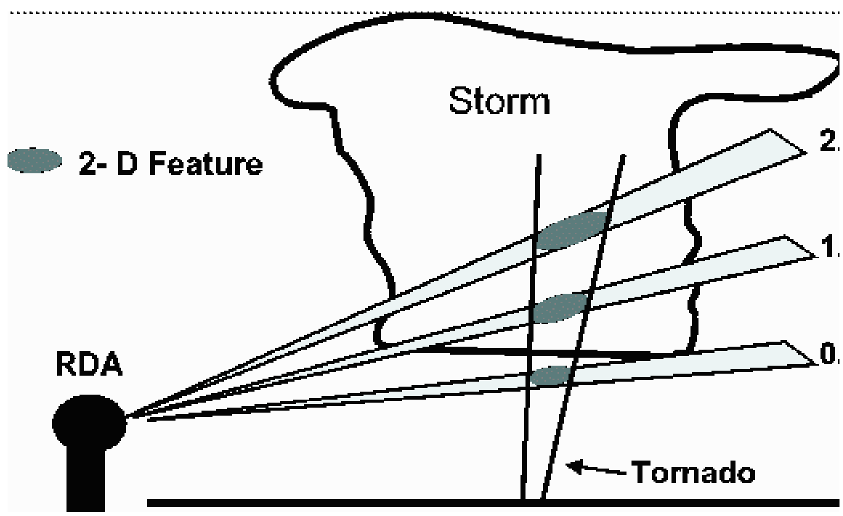


Figure 5-92. Vertically correlated 2-D circulations.

- Minimum Reflectivity (0 dBZ)
- Maximum Pattern Vector Range (100 km)
- Maximum Number of ETVSs (0)

Definitions and Symbology

TVS

A Tornadic Vortex Signature, TVS, is defined as a 3-D circulation with a base located on the 0.5° slice ***or*** below 600 meters ARL (above radar level) (see Fig. 5-93 on page 5-153). The depth of the circulation, maximum delta velocity anywhere in the circulation, and the delta velocity at the base of the circulation must exceed the adaptable parameters set (see previous section). The TVS symbol is displayed on the graphic product and overlay as a red, filled, inverted triangle. TVS symbols are placed at the azimuth and range of the lowest 2-D feature.

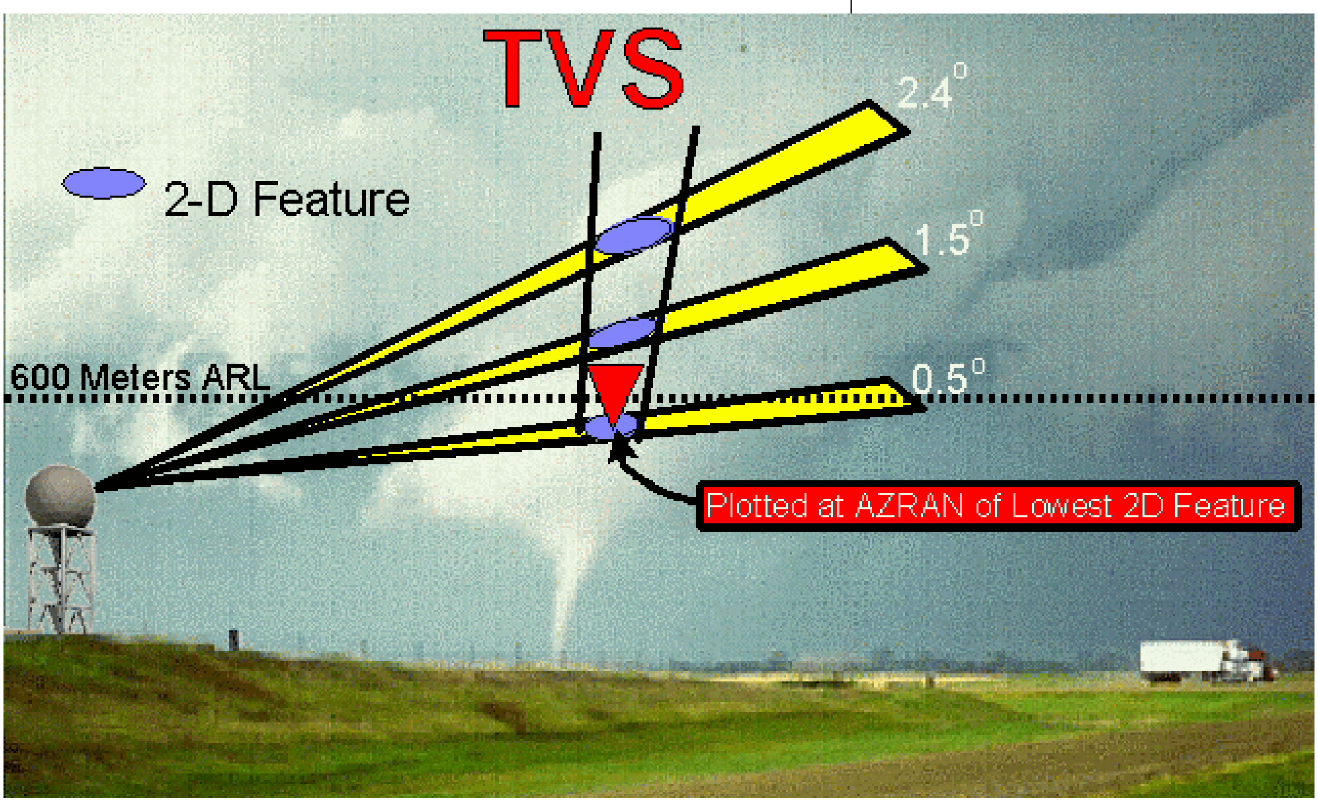


Figure 5-93. TVS definition.

ETVS

An Elevated Tornadic Vortex Signature, Elevated TVS or ETVS, is defined as a 3-D circulation with a base above the 0.5° slice ***and*** above 600 meters ARL (see Fig. 5-94). The depth of the circulation must be at least 1.5 km. Additionally, the thresholds of depth, max delta velocity and low level delta velocity must be exceeded. The ETVS symbol is displayed on the TVS overlay and the TVS graphic product as a red, open, inverted triangle as shown in Figure 5-95, and is placed at the azimuth and range of the lowest 2-D feature

Note that an Elevated TVS may possess a larger value of maximum shear somewhere in the storm column as compared to a TVS, but if there is no circulation on the 0.5° slice or below 600 meters, it cannot be defined as a TVS, despite possessing the higher shear.

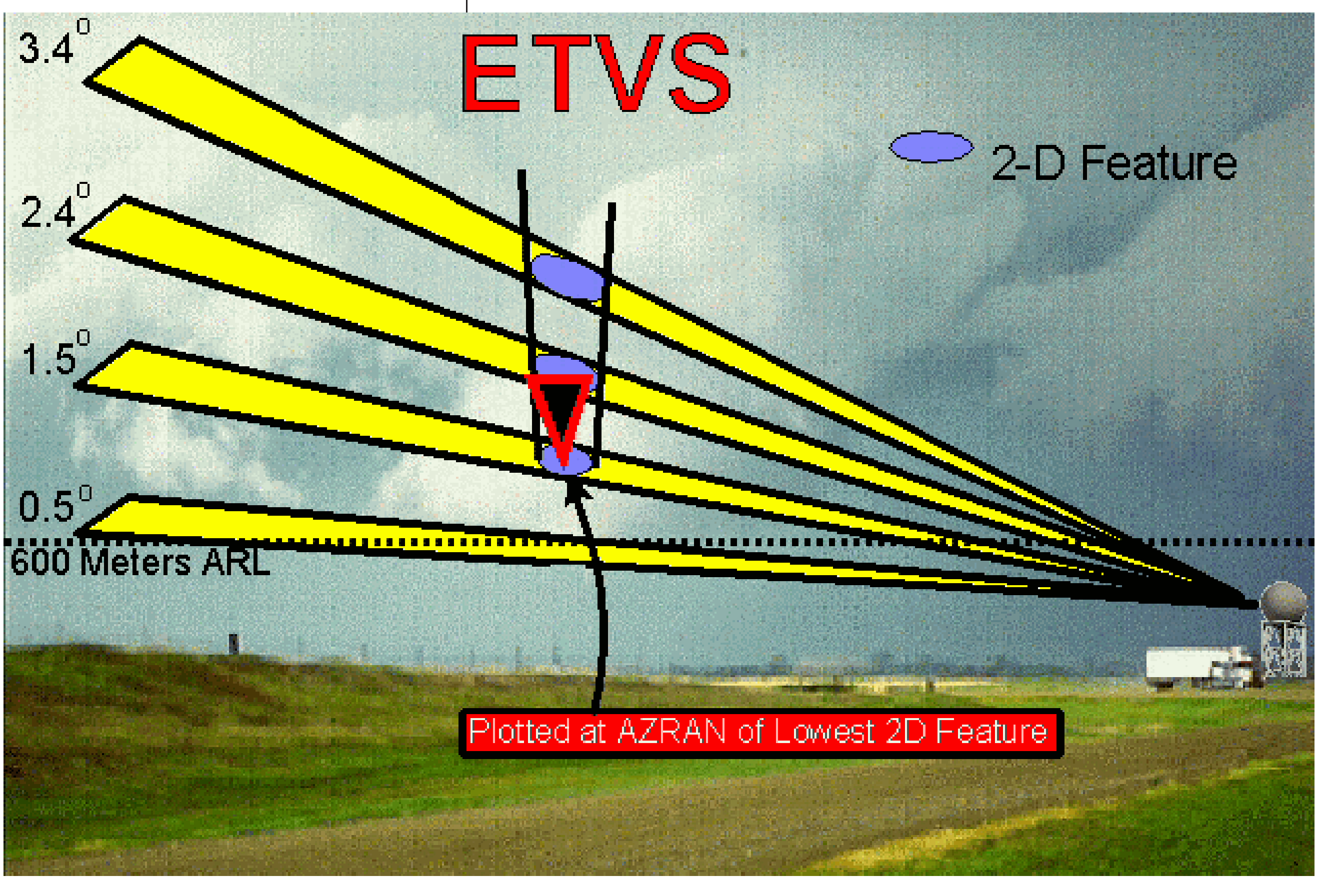


Figure 5-94. ETVS definition.

See Figure 5-95 for an example of the TVS product.

TVS product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Tornado Vortex Signature
- PAGE #: This is the page number of the attribute table.
- DATE: Day of week, time, and date in UTC

TVS product annotations

- TVS Attribute Table

Additional TVS product characteristics

- RANGE: 124 nm

TVS Product Parameters

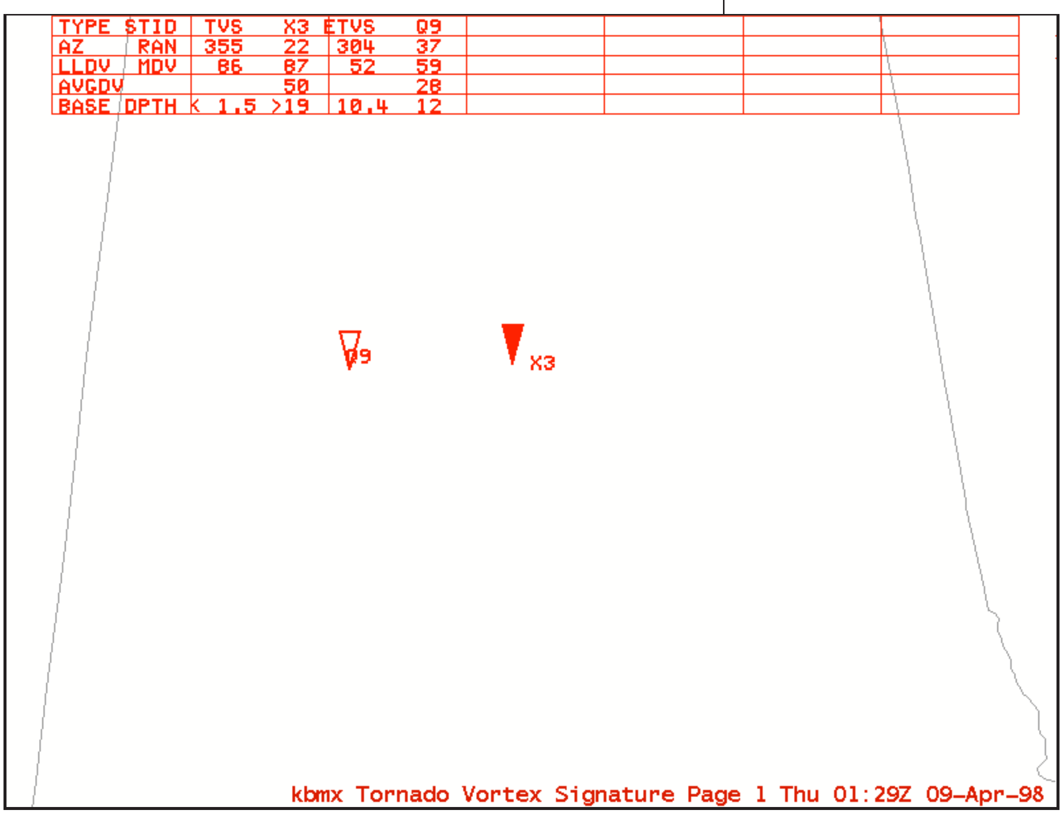


Figure 5-95. Example of TVS graphic product.

TVS Attribute Table

The TVS Attribute Table is available if any TVSs or ETVSs are detected. See Figure 5-96.

```
TYPE STID   TVS   X3   ETVS   Q9
AZ    RAN   355   22    304   37
LLDV  MDV    86   87     52   59
AVGDV             50          28
BASE DPTH  <1.5  >19    10.4  12
```

Figure 5-96. TVS Attribute Table which appears at the top of the TVS product.

Definitions

- **LLDV**: Low-Level Delta Velocity, in knots (Greatest velocity difference of lowest 2-D circulation)
- **MDV**: Maximum Delta Velocity, in knots (Greatest velocity difference of any 2-D circulation)
- **AVGDV**: Average Delta Velocity, in knots (Average weighted velocity difference of all 2-D circulations)
- **BASE**: Lowest altitude of the 3-D circulation, in Kft (Altitude of the lowest 2-D circulation)
- **DPTH**: Depth of the 3-D circulation, in Kft (Height difference between the lowest and highest 2-D circulation)

If a circulation exists at either 0.5° or 19.5°, then the depth of the circulation (DPTH) is estimated, and a > (greater than) symbol will be displayed with the stated depth. Similarly, if the circulation exists at 0.5°, the base (BASE) of the circulation is estimated, and a < (less than) symbol will be used with the stated base altitude (see Fig. 5-97 on page 5-157).

TVS Alphanumeric Product

The TVS Adaptation Data can be displayed at the AWIPS Text Display Window (WSRTVSxxx). This can be used to determine the adaptable parameter settings used to generate the product. See Fig. 5-97 on page 5-157.

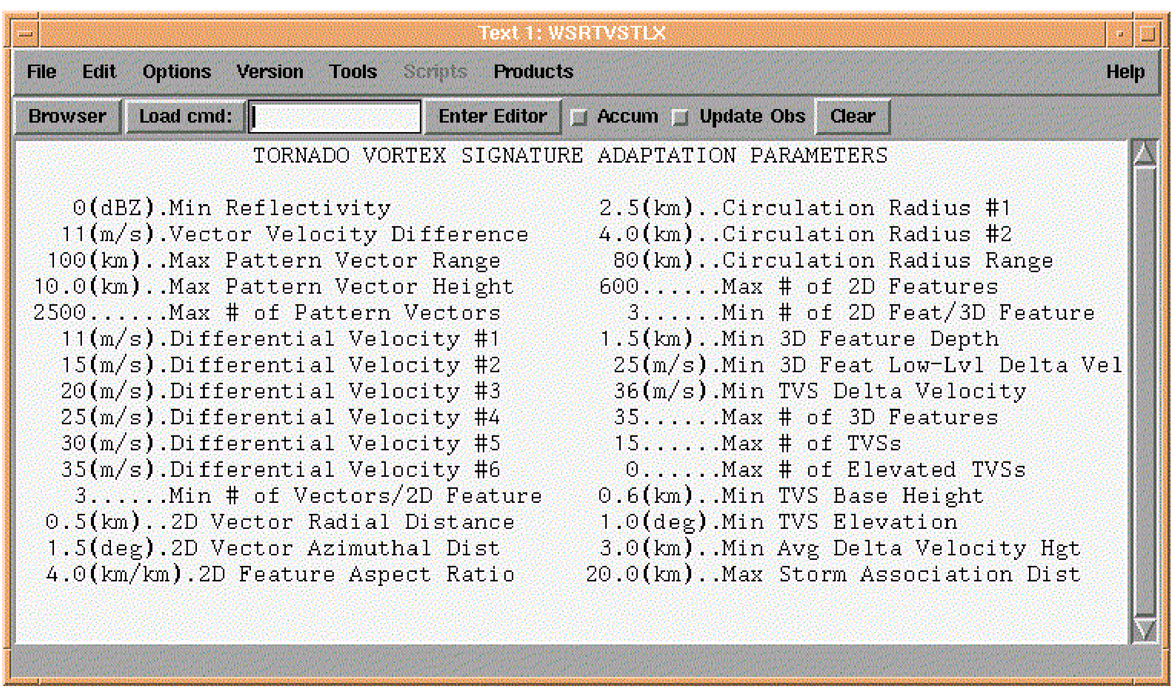
Radar Display Controls (ETVS Display Toggle)

Depending on which adaptable parameter settings are invoked, it is possible to have a situation when the display becomes cluttered with Elevated TVS symbols, making product interpretation difficult. For this reason, operators have been given control over whether or not ETVS symbols are displayed on the TVS graphic product and overlay (see Fig. 5-98 on page 5-158) .

This toggle does not affect the TVS attribute table or the TVS alphanumeric product or other AWIPS workstations. It is a graphic display function only. If the ETVS symbol is toggled to "off", a situation could arise where outside users are getting ETVSs, but the AWIPS graphic product is not displaying this information.

Operational Considerations

When a TVS detection occurs, consider the environmental wind and thermal profile, the signatures position in relation to the storm with which it is associated, time continuity, and the storm's range from the radar. Beyond



```
Text 1: WSRTVSTLX
File  Edit  Options  Version  Tools  Scripts  Products  Help
Browser  Load cmd:  Enter Editor  Accum  Update Obs  Clear

                TORNADO VORTEX SIGNATURE ADAPTATION PARAMETERS

   0(dBZ).Min Reflectivity             2.5(km)..Circulation Radius #1
  11(m/s).Vector Velocity Difference   4.0(km)..Circulation Radius #2
 100(km)..Max Pattern Vector Range      80(km)..Circulation Radius Range
10.0(km)..Max Pattern Vector Height    600......Max # of 2D Features
2500......Max # of Pattern Vectors       3......Min # of 2D Feat/3D Feature
  11(m/s).Differential Velocity #1     1.5(km)..Min 3D Feature Depth
  15(m/s).Differential Velocity #2      25(m/s).Min 3D Feat Low-Lvl Delta Vel
  20(m/s).Differential Velocity #3      36(m/s).Min TVS Delta Velocity
  25(m/s).Differential Velocity #4      35......Max # of 3D Features
  30(m/s).Differential Velocity #5      15......Max # of TVSs
  35(m/s).Differential Velocity #6       0......Max # of Elevated TVSs
   3......Min # of Vectors/2D Feature  0.6(km)..Min TVS Base Height
 0.5(km)..2D Vector Radial Distance    1.0(deg).Min TVS Elevation
 1.5(deg).2D Vector Azimuthal Dist     3.0(km)..Min Avg Delta Velocity Hgt
 4.0(km/km).2D Feature Aspect Ratio   20.0(km)..Max Storm Association Dist
```

Figure 5-97. TVS adaptable parameters displayed at the AWIPS Text Display Window.

about 60 km, the TVS will most likely be triggered by a strong mesocyclone and not all mesocyclones produce a tornado. Since the TDA works independently of the mesocyclone algorithm, the detection of a mesocyclone coincident with the TVS may support issuing a tornado warning. If the TVS is adjacent to a strong reflectivity gradient especially near the back of a storm, near a notch on the right rear flank of a storm, or near the tip of an appendage attached to the right rear flank of a storm, then the forecaster should give greater consideration to issuing a tornado warning.

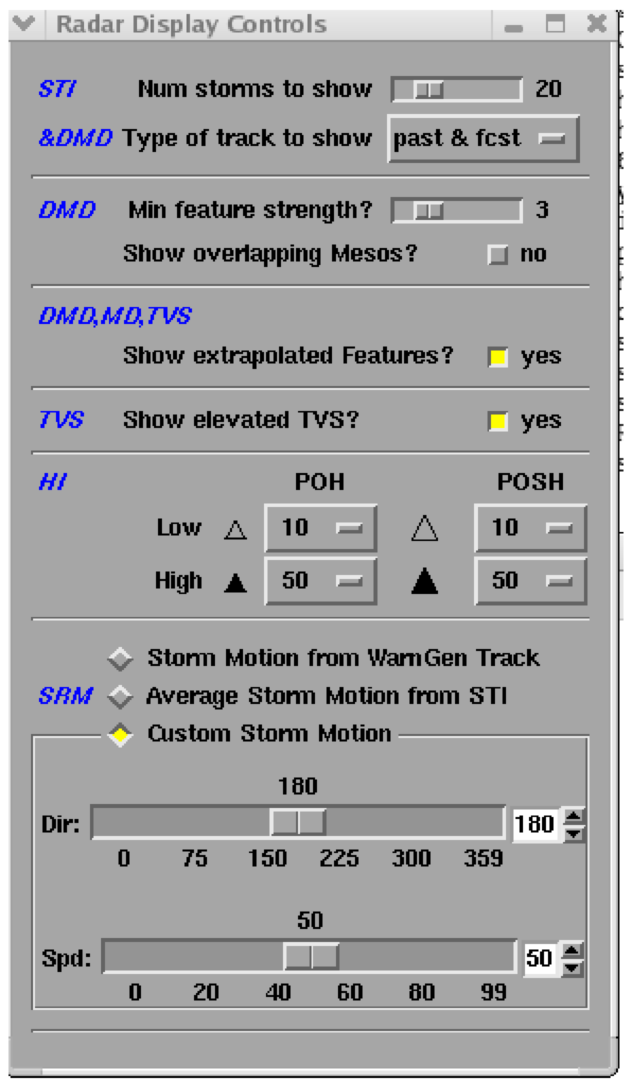


Figure 5-98. Radar Display Controls Edit Screen.

Because of its sensitivity, the TDA shows continuity in time and space. TVS detections for the same storm on two or more consecutive volumes can suggest the validity of issuing a tornado warning. The TDA has identified TVSs nearly continuously on long-lived supercells typical of the Great Plains, especially ones that cyclically produce tornadoes. In the South and the Southeast, tornadoes may be embedded within squall lines. The TDA tends to identify TVSs near the bend in a line echo wave pattern along the interface between warm moist inflow and storm outflow. While many of the TVSs are false alarms, tornadoes do occasionally spin up under these conditions.

Elevated TVSs are routinely generated by the TDA, but naturally do not score statistically as well as TVSs. However, ETVSs may be used as indicators of rotation aloft that could, with sufficient vorticity near the ground, produce a tornado. That is, they can be used to provide better lead times for identifying storms with the potential to produce tornadoes. A second use is to fill in gaps in TVS detections. Sometimes vertical continuity cannot be established between the lowest elevation and higher elevations. Other times ground clutter or range folding precludes measuring high gate-to-gate velocity differences. An elevated TVS may provide the time continuity to give a forecaster confidence to issue a tornado warning. ***One should be cautious about issuing a tornado warning based solely on ETVSs.***

Remember that algorithms serve to provide users with guidance. Ultimately, the decision to issue or not to issue a warning is up to the individual forecaster using all available data, including spotter reports.

TVS Limitations

1. **Adaptable parameters need more research.** Parameters which work well in one type of meteorological setting may not be as effective in other situations.
2. **High false alarm rates especially in squall lines and tropical cyclones.** A high FAR with TDA may result in over-warning, or desensitizing forecasters.
3. **Little research has been done to date relating the occurrence of tornadoes to Elevated TVSs.** Forecasters should use ETVS output with caution until they develop a better understanding of its utility.

TVS Applications (Strengths)

1. **The algorithm searches for gate-to-gate shear**, which is related to tornadic circulations.
2. **Multiple velocity-difference thresholds make it possible to isolate small regions of shear within broader regions.**
3. **A distinction is made between different types of shears** (TVS vs. ETVS, delta velocity calculations), and more information is provided about the base and depth of circulations.
4. **The algorithm, through a large number of adaptable parameters, allows fine-tuning of algorithm performance,** resulting in a higher probability of detecting operationally important shear regions.

TVS Rapid Update (TRU)

The TVS Rapid Update (TRU) generates a product for each elevation angle (in Precipitation Mode) through a volume scan using the results of the Tornado Detection Algorithm (TDA).

The TRU products closely resembles the format of the TVS product but with the following differences:

- In the graphic attributes table (see Fig. 5-99 on page 5-161) and the tabular alphanumeric product (see Fig. 5-100 on page 5-161), the symbol **^** will be next to data that is updated with respect to previous volume scan data

- The graphically displayed icons will distinguish between **extrapolated** and current TVS and ETVS features (see Fig. 5-101 on page 5-162).

TYPE STID	TVS B2	ETVS ^ C0	ETVS ^ B2	ETVS ^ U2	ETVS ^ U2	ETVS ^ G2
AZ RAN	307 54	294 ^ 30	301 ^ 50	281 ^ 30	286 ^ 29	338 ^ 45
LLDV MDV	57 57	^ 61 ^ 82	^ 59 ^ 84	^ 58 ^ 58	^ 52 ^ 52	^ 51 ^ 56
STA AVGDV	EXT 34	NEW ^ 16	NEW ^ 31	NEW ^ 19	NEW ^ 21	NEW ^ 17
BASE DPTH	7.1 8	16.7^ 14	8.4^ 21	16.8^ 9	13.1^ 12	16.2^ 15

Figure 5-99. TRU Attributes Table.

TVS Rapid Update

RADAR ID: 302 DATE: 05/09/2003 TIME: 23:58:42 TVS/ETVS: 1/ 6 ELEV: 15.6

FEATURE STA	TYPE	STORM ID	AZ/RAN (deg,nm)	AVGDV (kt)	LLDV (kt)	MXDV/Hgt (kt,kft)	Depth (kft)	Base/Top (kft)	MXSHR/Hgt (E-3/s,kft)
EXT	TVS	B2	307/ 54	34	57	57/ 7.1	8.5	7.1/ 15.5	17/ 7.1
NEW	ETVS^	C0	294/ 30^	16^	61^	82/30.7^	14.1^	16.7/ 30.7^	46/30.7^
NEW	ETVS^	B2	301/ 50^	31^	59^	84/23.6^	21.2^	8.4/ 29.6^	26/23.6^
NEW	ETVS^	U2	281/ 30^	19^	58^	58/16.8^	8.7^	16.8/ 25.5^	31/16.8^
NEW	ETVS^	U2	286/ 29^	21^	52^	52/13.1^	12.4^	13.1/ 25.5^	28/13.1^
NEW	ETVS^	G2	338/ 45^	17^	51^	56/20.9^	15.2^	16.2/ 31.4^	20/20.9^
NEW	ETVS^	C0	292/ 28^	18^	50^	50/15.6^	7.9^	15.6/ 23.5^	28/15.6^

Figure 5-100. TRU Alphanumeric Product.

TRU Graphical Product

The TRU graphical product uses traditional TVS (filled in red triangle) and ETVS (open red triangle) symbols. For extrapolated (detection from previous volume scan unmatched to current volume scan) detection a filled right triangle is used.

Matching Features

All features (TVS and ETVS) identified on the previous volume scan are projected to move at the average motion of all cells identified by the SCIT algorithm. Until a match is made with a feature on

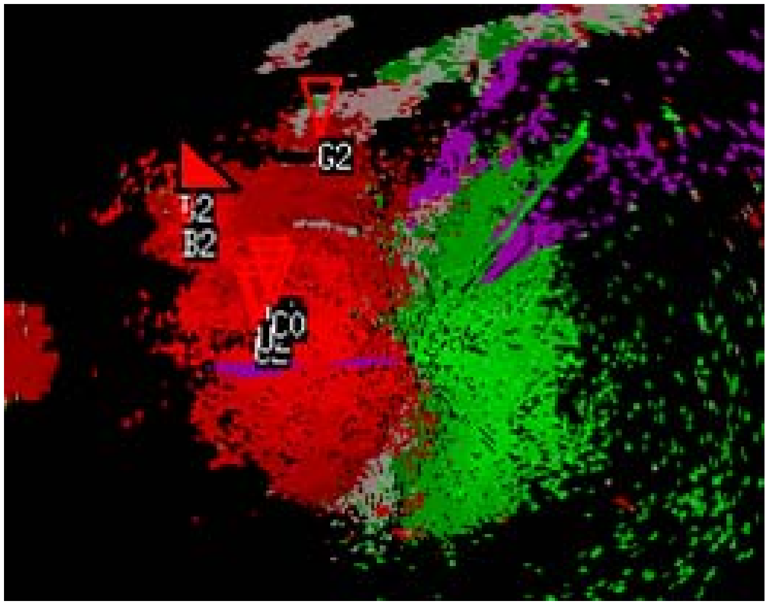


Figure 5-101. TRU Graphic Product. Note the extrapolated (unmatched) detection associated with cell B2 that is annotated with a filled right triangle.

the current volume scan, the feature is marked as **extrapolated** (filled right triangle on the graphic product). If a match is not made within a search radius (default 10 km) by the end of the volume scan, the EXT feature is dropped.

If there is a match

If there is a match, the current feature initially inherits the attributes of the previous feature. These attributes include:

- associated storm id
- feature type (TVS or ETVS)
- low-level delta velocity (LLDV)
- maximum delta velocity (MDV)
- average delta velocity (AVGDV)
- maximum shear
- height, base and top heights, depth

The position attributes base azimuth, range and height are updated to the current detection.

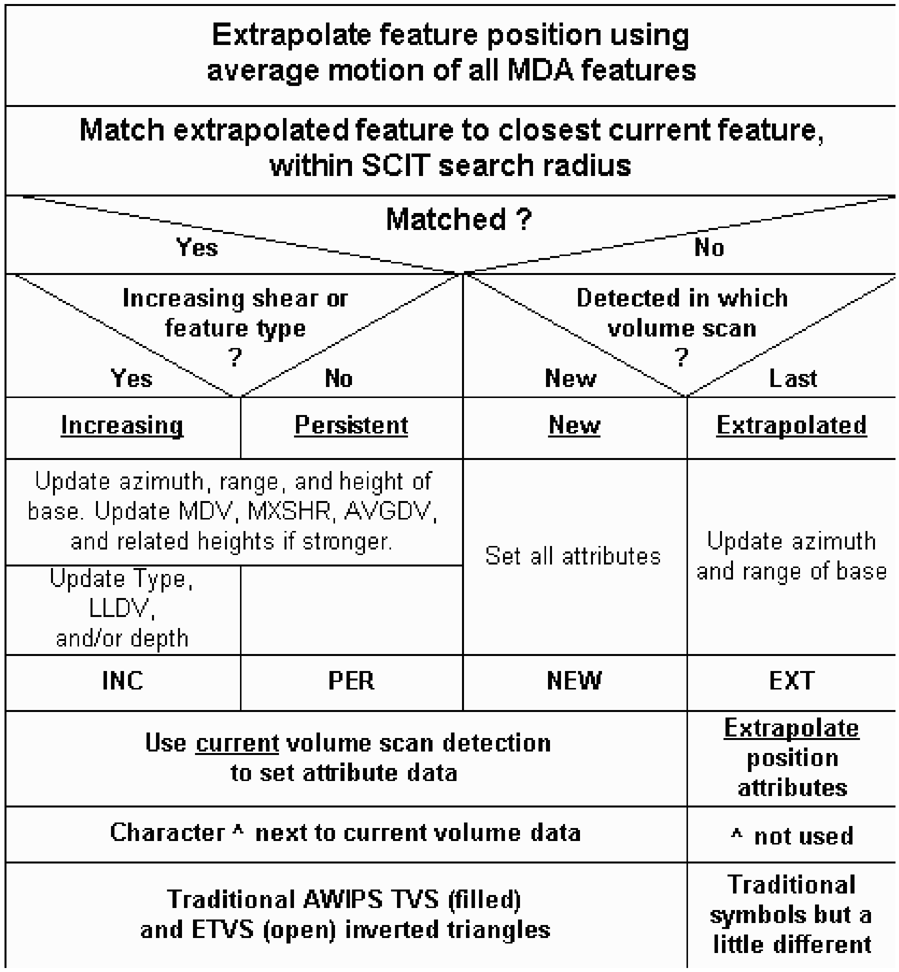


Figure 5-102. TRU Matching Process. There are four types of detections on the TRU: **INC** (increasing), **PER** (persistent), **NEW** (new), and **EXT** (extrapolated).

Increasing or Persistent

A feature on the current volume scan that can be matched to a feature on the previous volume scan are categorized as **INC** (increasing) or **PER** (persistent) based on whether there is an increase in any of the “strength attributes”:

- feature type (TVS or ETVS)
- low-level delta velocity (LLDV)
- depth

If none of the “strength attributes” increase, the feature is assigned the status PER (persistent) (see Fig. 5-102 on page 5-163).

Requesting TRU

The AWIPS user can request the TRU product via RPS list or one-time requests. A request can be made at one or several elevation angles. The elevation angle field in the product request message can be used to specify an elevation angle (e.g., send me the TRU at the end of the 1.5 degree cut), or how many of the lowest scans below a specific angle (e.g., send me all elevations below 5 degrees elevation), or to provide all elevation scans (i.e., send me a TRU at the end of each elevation scan).

TRU Product Limitations

1. **Classification as INC (increasing) or (PER) persistent may be the result of sampling issues versus an actual change of the feature.**
2. **The TRU graphical attribute table and alphanumeric product contain attributes from both the previous and current volume scan.**
    - Pay particular attention to the **^** symbol that indicates the attribute is from the current volume scan.
3. **Feature matching ability is dependent on the motion supplied by the MDA (average motion of all MDA features).**
    - This motion could be very different than the motion of the TVS feature.

TRU Product Applications (Strengths)

1. **Intermediate Tornado Detection Algorithm (TDA) is available before end of volume scan.**
2. **TRU tracks features to develop time continuity.**

Interim Summary

Mesocyclone Detection (MD) and Digital Mesocyclone Detection (DMD) Products

1. Detections on the MD product must be investigated for validity using Base Velocity or SRM.
2. If a mesocyclone is detected in the velocity field before the algorithm, don't wait for a mesocyclone symbol from the algorithm to take the appropriate action.
3. Adaptable parameters will need to be adjusted to various meteorological situations.

TVS Product

1. The TVS product can be useful in alerting the operator of significant and possibly tornadic circulations.
2. Many TVS detections (especially in squall line and tropical cyclone situations do not produce tornadoes.

TVS Rapid Update

1. Output from TDA algorithm available at each elevation scan, allowing operator to view output before end of volume scan.
2. Feature matching dependent on motion supplied by SCIT algorithm.

Lesson 5: Precipitation Products

Overview

This lesson will present the precipitation products generated by the WSR-88D. The primary set of algorithms that produce the precipitation products is the Precipitation Processing Subsystem (PPS). The PPS was covered in Topic 3, Lesson 6 “Precipitation Estimation.” This section includes a brief review of the PPS, and assumes the student has completed Topic 3, Lesson 6.

Review of Precipitation Processing Subsystem (PPS)

The precipitation algorithms commonly called the Precipitation Processing Subsystem (PPS) contain numerous quality control steps (see Fig. 5-103 on page 5-168). Since radar only indirectly measures precipitation rates, extensive quality control is applied to get the best possible rainfall estimates.

Because of the quality control steps used in the PPS, the operator will notice a difference between the reflectivity data used as input and the corresponding precipitation products.

Rainfall estimates are only provided out to 124 nm. No estimates are generated beyond 124 nm because errors increase rapidly beyond that range.

The algorithms in the PPS are highly flexible with many adaptable parameters. The process of tailoring adaptable parameters for each radar site requires research and observations from the field users of the system. Changes in most adaptable parameter settings requires coordination with the ROC and the Office of Hydrology.

The four algorithms of the PPS discussed in Topic 3, Lesson 6 are:

1. Enhanced Precipitation Preprocessing (EPRE)
   - Determines start and stop of accumulations
   - Reduces impact of residual clutter
   - Constructs the Hybrid Scan (reflectivity to be used to convert to rainfall rate)
2. Precipitation Rate
   - Converts reflectivity in the Hybrid Scan to rainfall rate using Z-R relationship
   - Reduces resolution to 1.1 nm x 1 degree
3. Precipitation Accumulation
   - Scan to scan accumulations
   - Hourly accumulations
   - Adjusts for missing data
4. Precipitation Adjustment
   - Compares radar accumulation estimates to rain gauges
   - Uses multiplicative bias adjustment to account for non-representative Z-R relationships or incorrect hardware calibration

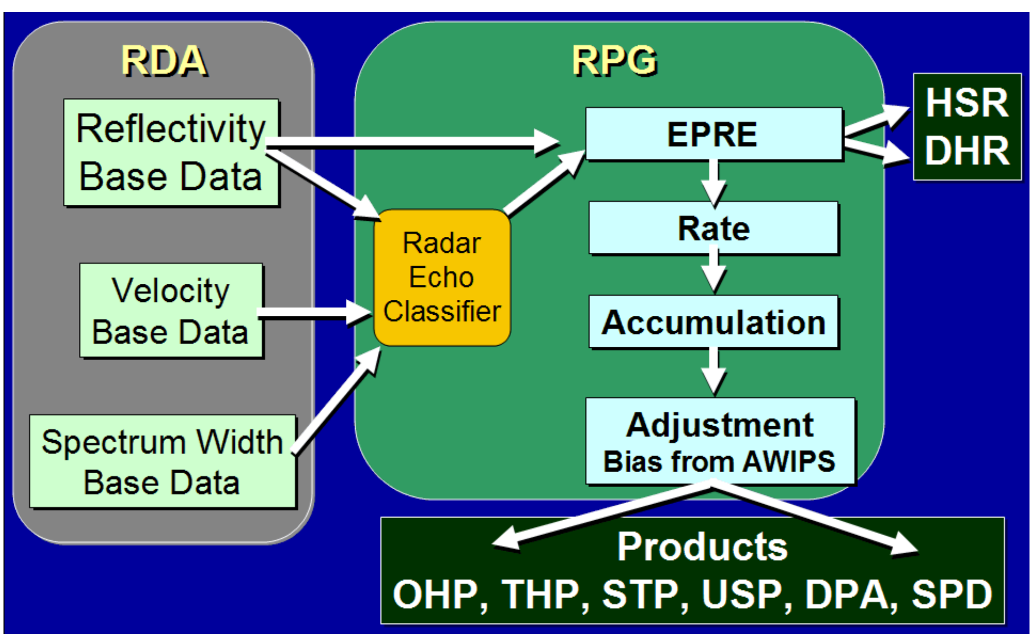


Figure 5-103. Precipitation Processing Subsystem overview from Topic 3 Lesson 6.

Objectives

Upon completion of this lesson you will be able to identify specific characteristics, limitations, and applications (strengths) of the following products:

1. Hybrid Scan Reflectivity (HSR)
2. Digital Hybrid Scan Reflectivity (DHR)
3. One Hour Precipitation (OHP)
4. Three Hour Precipitation (THP)
5. Storm Total Precipitation (STP)
6. User Selectable Precipitation (USP)
7. One Hour Digital Precipitation Array (DPA)
8. Supplemental Precipitation Data (SPD)

Hybrid Scan Reflectivity (HSR)

The Hybrid Scan Reflectivity (HSR) product is a **16 data level** reflectivity product output from the Enhanced Precipitation Preprocessing (EPRE) algorithm and used for most of the **RPG** produced precipitation products (see Fig. 5-104 on page 5-170).

HSR product legend description:

- RPG ID: kxxx
- PRODUCT NAME: 4 bit Hyb Scan Refl
- UNITS: (dBZ)
- DATE: Day of week, time, and date **in UTC**

HSR product annotations:

- VCP: 11, 12, 21, 121, 31 or 32

Additional HSR product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 0.54nm X 1 degree
- DATA LEVELS: 16 data levels from +5 dBZ to + 75 dBZ.

Available every volume scan

Note: The HSR product is a 4-bit (16 data level) product not to be confused with the Digital Hybrid Scan Reflectivity (DHR) product that is 8-bit (256 data levels).

Hybrid Scan Reflectivity Limitations

1. **Ground clutter and AP is sometimes displayed on the Hybrid Scan Reflectivity.**

Hybrid Scan Reflectivity Applications (Strengths)

1. **View reflectivity used for precipitation products.**
2. **Assess the accuracy of the precipitation products.**
3. **Quickly search for inconsistencies in the data.**
4. **Assist operator in discriminating between precipitation returns and ground returns due to anomalous propagation.**

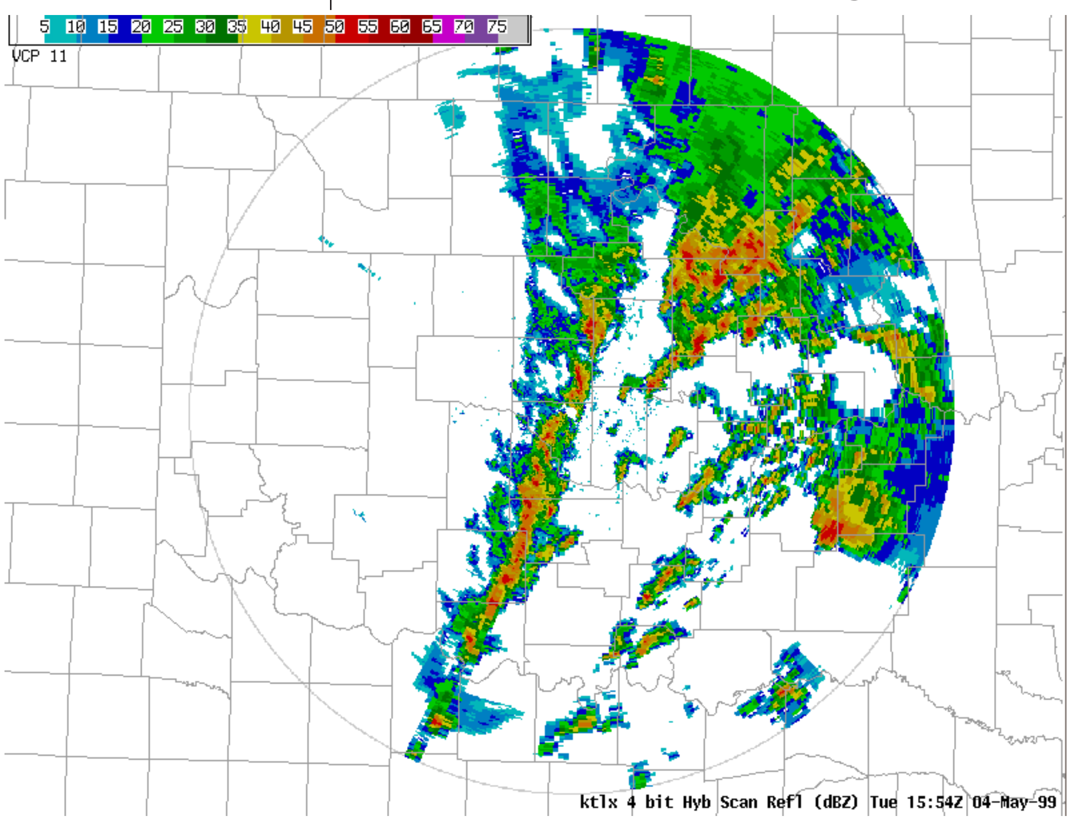


Figure 5-104. Hybrid Scan Reflectivity (HSR)

Digital Hybrid Scan Reflectivity (DHR)

The Digital Hybrid Scan Reflectivity (DHR) product is a **256 data level** reflectivity product output from the Enhanced Precipitation Preprocessing (EPRE) algorithm (see Fig. 5-105 on page 5-172). The DHR is used for applications **external** to the RPG such as Flash Flood Monitoring and Prediction (FFMP).

DHR product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Hybrid Scan Refl
- UNITS: (dBZ)
- DATE: Day of week, time, and date **in UTC**

DHR product annotations:

- VCP: 11, 12, 21, 121, 31 or 32

Additional DHR product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- DATA LEVELS: 256 data levels from -28 dBZ to + 90 dBZ. (0.5 dBZ increments)

Available every volume scan.

Digital Hybrid Scan Reflectivity (DHR) Limitation

1. **Large product size**

Digital Hybrid Scan Reflectivity (DHR) Applications (Strengths)

1. **High resolution (256 data levels) allows for innovative color tables.**
2. **High accuracy (0.5 dBZ).**
3. **Used in the generation of external products.**
   - Flash Flood Monitoring and Prediction (FFMP)
   - Jendrowski Scripts (Multiple Z/R AWIPS App)
   - Areal Mean Basin Estimated Rainfall - AMBER

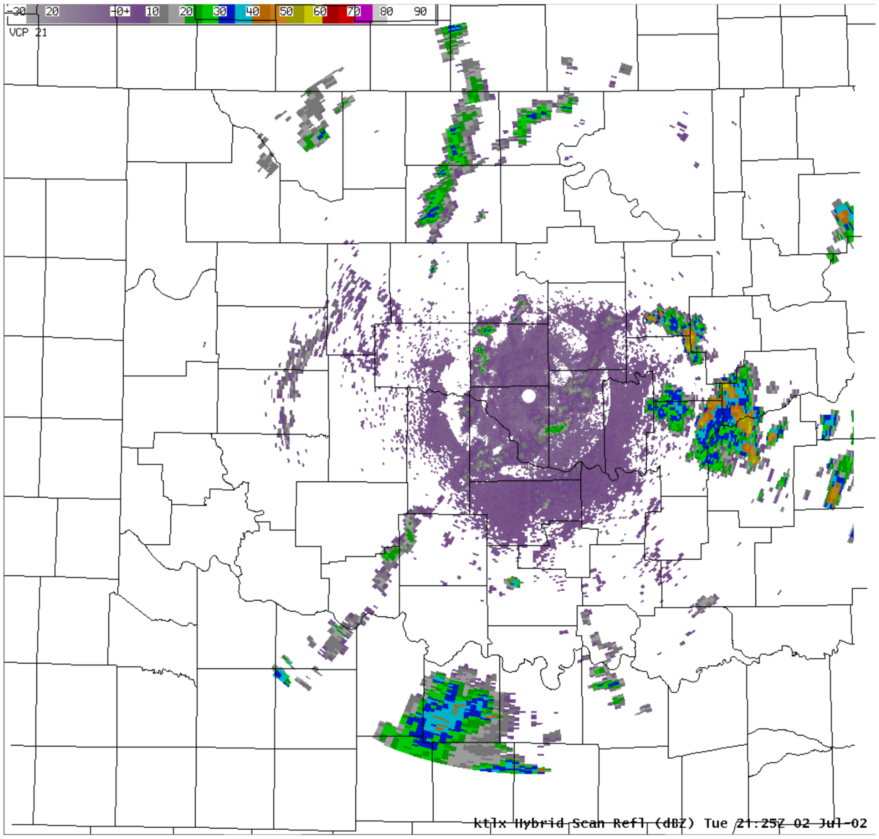


Figure 5-105. Digital Hybrid Scan Reflectivity (DHR)

Interim Summary

Hybrid Scan Reflectivity (HSR) Product

The Hybrid Scan Reflectivity (HSR) product is a **16 data level** reflectivity product output from the Enhanced Precipitation Preprocessing (EPRE) algorithm that is used for most of the **RPG-**produced precipitation products.

Digital Hybrid Scan Reflectivity (DHR) Product

The Digital Hybrid Scan Reflectivity (DHR) product is a **256 data level** reflectivity product output from the Enhanced Precipitation Preprocessing (EPRE) algorithm that is mostly used for the products **external** to the RPG such as the AWIPS generated Flash Flood Monitoring and Prediction (FFMP) application.

Precipitation Accumulation Products

- One Hour Precipitation (OHP)
- Three Hour Precipitation (THP)
- Storm Total Precipitation (STP)
- User Selectable Precipitation (USP)
- One Hour Digital Precipitation Array (DPA)
- Supplemental Precipitation Data (SPD)

One Hour Precipitation

OHP product legend description: (Fig. 5-106)

- RPG ID: kxxx
- PRODUCT NAME: One Hour Precip
- UNITS: (in)
- DATE: Day of week, time, and date **in UTC**

OHP product annotations:

- VCP: 11, 12, 21, 121, 31 or 32
- MX: This is the maximum accumulation of precipitation on the product. The location of this value is unknown.
- BIAS/ERR: The multiplicative bias is displayed whether or not the Bias Flag at the RPG is set to True or False.
- END: This is the date/time for the accumulations computed by the PPS for the particular volume scan.

Additional OHP product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 1.1nm x 1 degree
- DATA LEVELS: 16 data levels available, with a range of 0.00 to 12.70 inches in multiples of 0.05 inch. Data level values are selected at the RPG HCI under URC change authority.
- Paired Alphanumeric Product (see Fig. 5-107)

Displays accumulations for the past hour.

Available from the first volume scan with detected rainfall (from EPRE) except when there is missing data (radar outage of more than 30 minutes).

Updated every volume scan after the first product - a **moving one hour window of precipitation**.

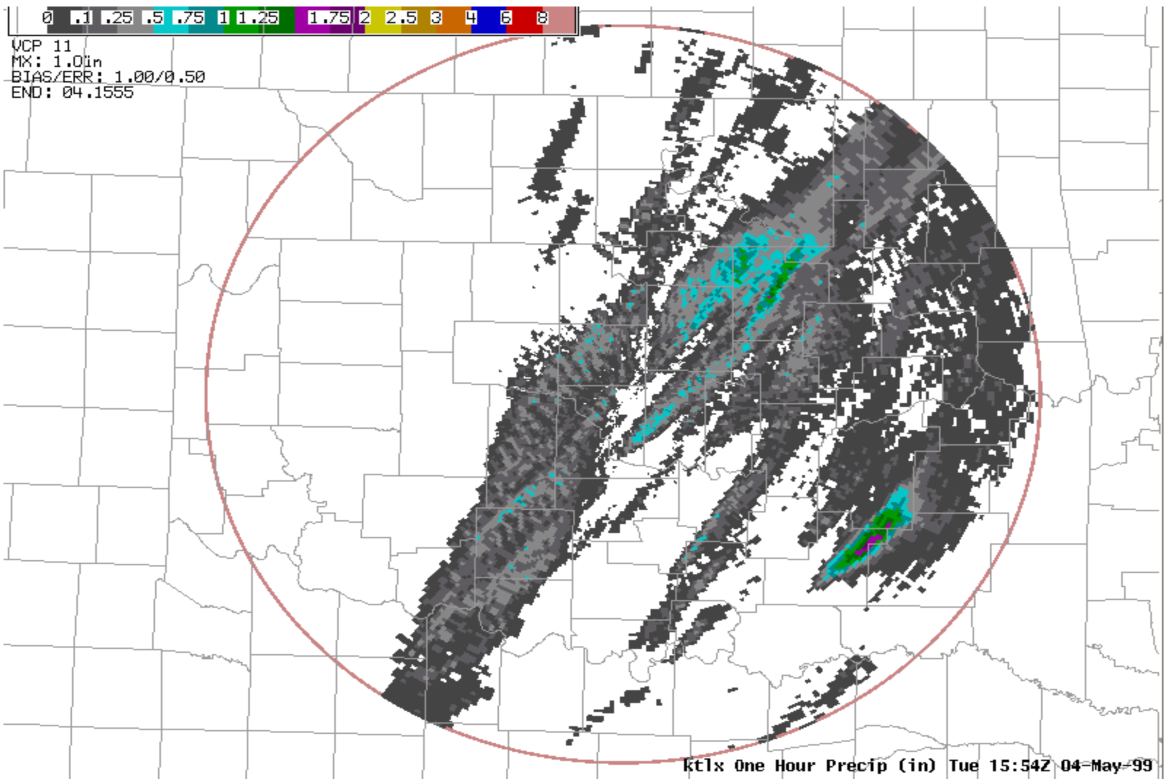


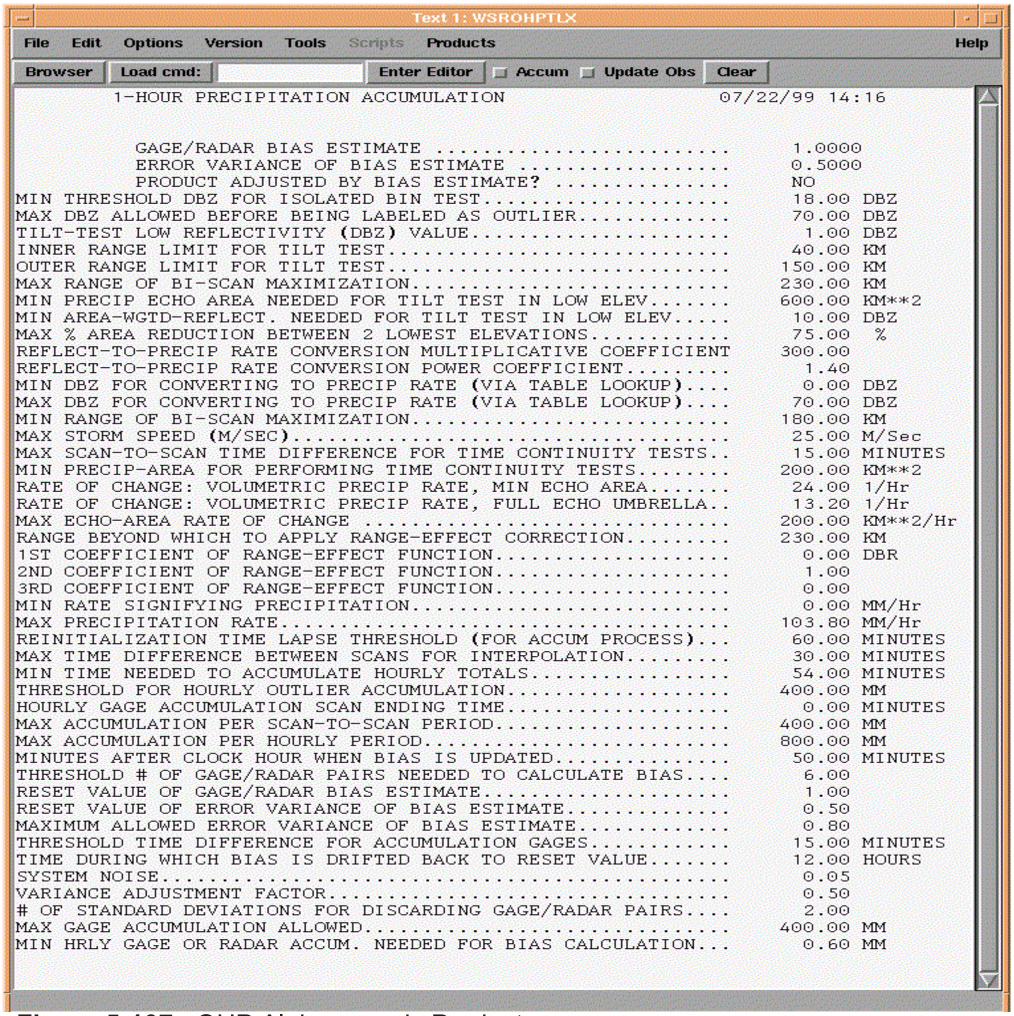
Figure 5-106. One Hour Precipitation (OHP)

One Hour Precipitation Limitations

1. **After extended outages, first product will not be generated for 54 minutes**
2. **For some events, viewing interval too short**

One Hour Precipitation Applications (Strengths)

1. **Assess rainfall accumulations for flash flood watches, warnings, and statements**
2. **Nowcasts and special weather statements**
3. **Time lapse can provide storm movement**
4. **Other water management applications**



1-HOUR PRECIPITATION ACCUMULATION 07/22/99 14:16

GAGE/RADAR BIAS ESTIMATE	1.0000	
ERROR VARIANCE OF BIAS ESTIMATE	0.5000	
PRODUCT ADJUSTED BY BIAS ESTIMATE?	NO	
MIN THRESHOLD DBZ FOR ISOLATED BIN TEST....................	18.00	DBZ
MAX DBZ ALLOWED BEFORE BEING LABELED AS OUTLIER............	70.00	DBZ
TILT-TEST LOW REFLECTIVITY (DBZ) VALUE.....................	1.00	DBZ
INNER RANGE LIMIT FOR TILT TEST............................	40.00	KM
OUTER RANGE LIMIT FOR TILT TEST............................	150.00	KM
MAX RANGE OF BI-SCAN MAXIMIZATION..........................	230.00	KM
MIN PRECIP ECHO AREA NEEDED FOR TILT TEST IN LOW ELEV.......	600.00	KM**2
MIN AREA-WGTD-REFLECT. NEEDED FOR TILT TEST IN LOW ELEV.....	10.00	DBZ
MAX % AREA REDUCTION BETWEEN 2 LOWEST ELEVATIONS............	75.00	%
REFLECT-TO-PRECIP RATE CONVERSION MULTIPLICATIVE COEFFICIENT	300.00	
REFLECT-TO-PRECIP RATE CONVERSION POWER COEFFICIENT.........	1.40	
MIN DBZ FOR CONVERTING TO PRECIP RATE (VIA TABLE LOOKUP)....	0.00	DBZ
MAX DBZ FOR CONVERTING TO PRECIP RATE (VIA TABLE LOOKUP)....	70.00	DBZ
MIN RANGE OF BI-SCAN MAXIMIZATION..........................	180.00	KM
MAX STORM SPEED (M/SEC)....................................	25.00	M/Sec
MAX SCAN-TO-SCAN TIME DIFFERENCE FOR TIME CONTINUITY TESTS..	15.00	MINUTES
MIN PRECIP-AREA FOR PERFORMING TIME CONTINUITY TESTS........	200.00	KM**2
RATE OF CHANGE: VOLUMETRIC PRECIP RATE, MIN ECHO AREA.......	24.00	1/Hr
RATE OF CHANGE: VOLUMETRIC PRECIP RATE, FULL ECHO UMBRELLA..	13.20	1/Hr
MAX ECHO-AREA RATE OF CHANGE	200.00	KM**2/Hr
RANGE BEYOND WHICH TO APPLY RANGE-EFFECT CORRECTION.........	230.00	KM
1ST COEFFICIENT OF RANGE-EFFECT FUNCTION....................	0.00	DBR
2ND COEFFICIENT OF RANGE-EFFECT FUNCTION....................	1.00	
3RD COEFFICIENT OF RANGE-EFFECT FUNCTION....................	0.00	
MIN RATE SIGNIFYING PRECIPITATION..........................	0.00	MM/Hr
MAX PRECIPITATION RATE......................................	103.80	MM/Hr
REINITIALIZATION TIME LAPSE THRESHOLD (FOR ACCUM PROCESS)...	60.00	MINUTES
MAX TIME DIFFERENCE BETWEEN SCANS FOR INTERPOLATION.........	30.00	MINUTES
MIN TIME NEEDED TO ACCUMULATE HOURLY TOTALS.................	54.00	MINUTES
THRESHOLD FOR HOURLY OUTLIER ACCUMULATION..................	400.00	MM
HOURLY GAGE ACCUMULATION SCAN ENDING TIME..................	0.00	MINUTES
MAX ACCUMULATION PER SCAN-TO-SCAN PERIOD....................	400.00	MM
MAX ACCUMULATION PER HOURLY PERIOD..........................	800.00	MM
MINUTES AFTER CLOCK HOUR WHEN BIAS IS UPDATED...............	50.00	MINUTES
THRESHOLD # OF GAGE/RADAR PAIRS NEEDED TO CALCULATE BIAS....	6.00	
RESET VALUE OF GAGE/RADAR BIAS ESTIMATE.....................	1.00	
RESET VALUE OF ERROR VARIANCE OF BIAS ESTIMATE..............	0.50	
MAXIMUM ALLOWED ERROR VARIANCE OF BIAS ESTIMATE.............	0.80	
THRESHOLD TIME DIFFERENCE FOR ACCUMULATION GAGES............	15.00	MINUTES
TIME DURING WHICH BIAS IS DRIFTED BACK TO RESET VALUE.......	12.00	HOURS
SYSTEM NOISE..	0.05	
VARIANCE ADJUSTMENT FACTOR..................................	0.50	
# OF STANDARD DEVIATIONS FOR DISCARDING GAGE/RADAR PAIRS....	2.00	
MAX GAGE ACCUMULATION ALLOWED...............................	400.00	MM
MIN HRLY GAGE OR RADAR ACCUM. NEEDED FOR BIAS CALCULATION...	0.60	MM

Figure 5-107. OHP Alphanumeric Product

Three Hour Precipitation

THP product legend description: (Fig. 5-108)

- RPG ID: kxxx
- PRODUCT NAME: Three Hour Precip
- UNITS: (in)
- DATE: Day of week, time, and date **in UTC**

THP product annotations:

- VCP: 11, 12, 21, 121, 31 or 32
- MX: This is the maximum accumulation of precipitation on the product. The location of this value is unknown.

- BIAS/ERR: Each hours multiplicative bias is displayed whether or not the Bias Flag at the RPG is set to True or False.
- END: This is the date/time for the accumulations computed by the PPS for the particular volume scan.

Additional THP product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 1.1nm x 1 degree
- DATA LEVELS: 16 data levels available, with a range of 0.00 to 12.70 inches in multiples of 0.05 inch. Data level values are selected at the RPG HCI, and are under URC change authority.
- Paired Alphanumeric Product (see Fig. 5-109)

Product accumulations **updated once per hour**, at the top of the hour.

Requires two out of past three top of the hour accumulations (zero or nonzero) for product generation.

Not recommended for RPS list.

Three Hour Precipitation Limitations

1. **Product updated only once per hour.**

Three Hour Precipitation Applications (Strengths)

1. **Provides a longer viewing interval.**
2. **For very long duration events, can be used with Storm Total Product for analysis.**
3. **Corresponds to timing of three hour flash flood guidance values.**

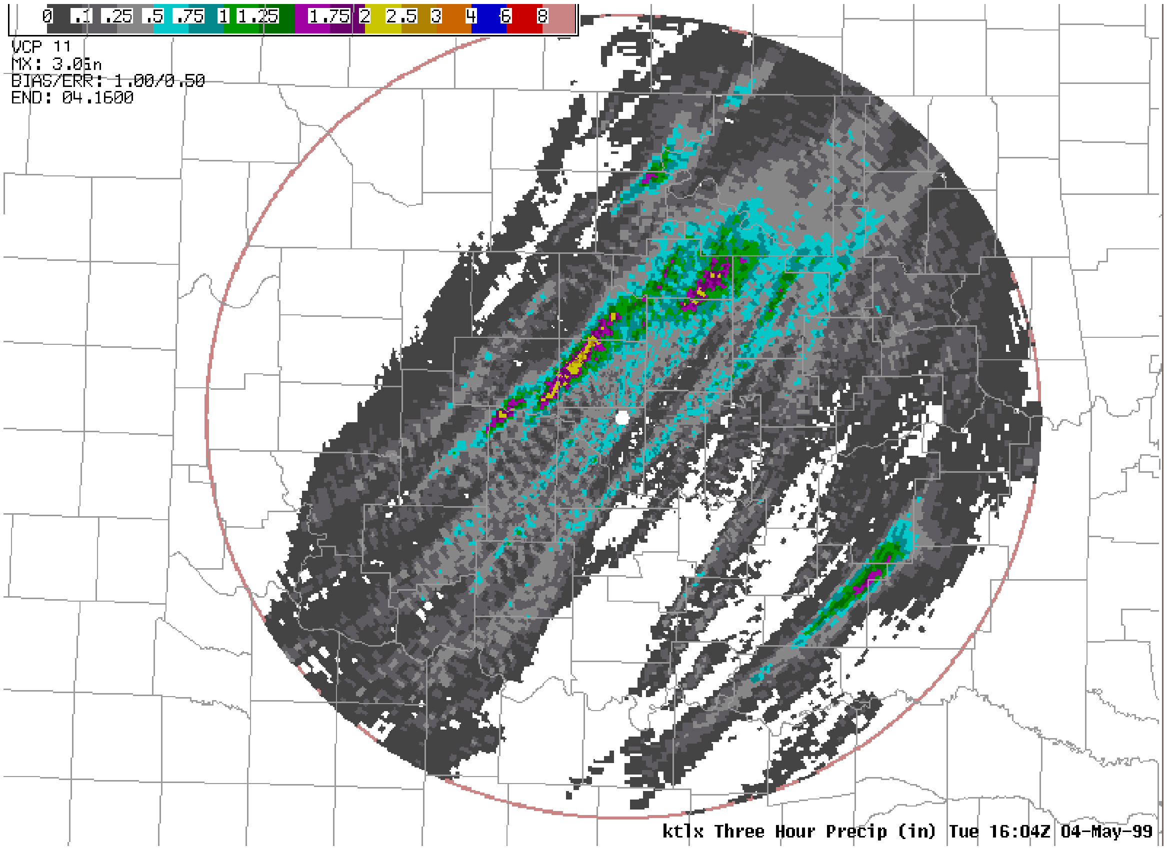


Figure 5-108. Three Hour Precipitation (THP)

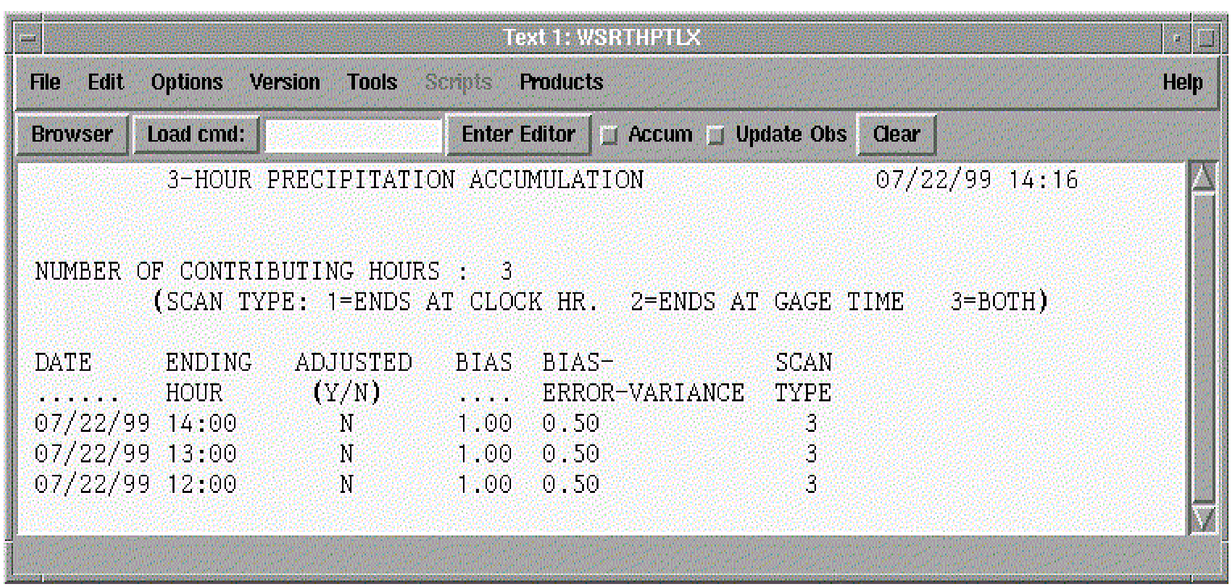


Figure 5-109. THP Alphanumeric Product

Storm Total Precipitation

STP product legend description: (Fig. 5-112)

- RPG ID: kxxx
- PRODUCT NAME: Storm Total Precip
- UNITS: (in)
- DATE: Day of week, time, and date **in UTC**

STP product annotations:

- VCP: 11, 12, 21, 121, 31 or 32
- MX: This is the maximum accumulation of precipitation on the product. The location of this value is unknown.
- BIAS/ERR: The most recent multiplicative bias is displayed whether or not the Bias Flag at the RPG is set to True or False.
- BEG: Date/time of the first volume scan accumulation began.
- END: End date/time for the accumulations displayed.

Additional STP product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 1.1nm x 1 degree
- DATA LEVELS: 16 data levels available, with a range of 0.00 to 25.4 inches in multiples of 0.1 inch. Data level values selected at the RPG HCI (URC change authority).

Displays **total rainfall accumulation**.

Available from the first volume scan with detected rainfall (as determined by EPRE).

Updated every volume scan as long as precipitation meets EPRE thresholds.

Accumulations reset to zero after one hour of no precipitation. Also, accumulations can be reset procedure in the RPG Control window (see Fig. 5-110). Selecting the Options button under Restart will bring up the RPG Init Options window. In this window, the URC password must first be provided.

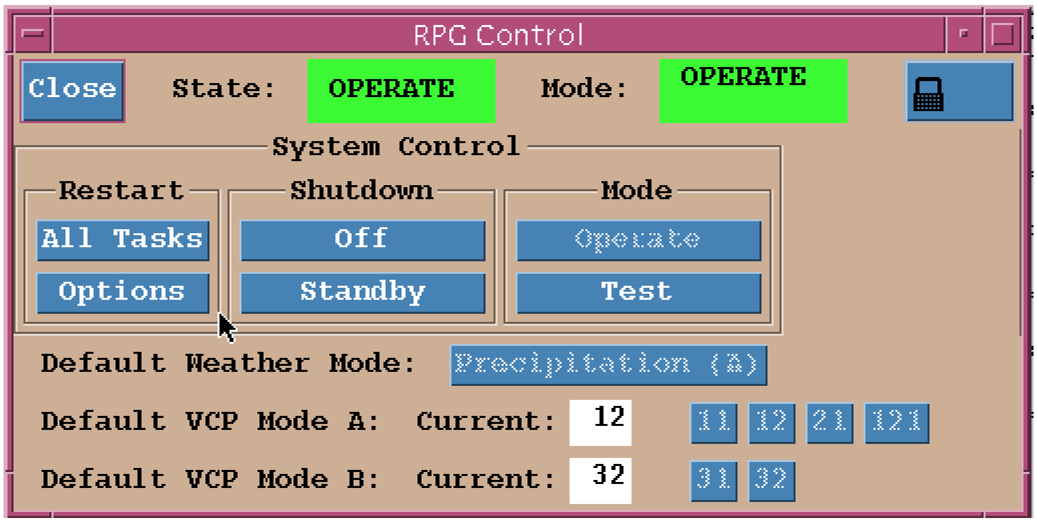


Figure 5-110. RPG Control Window. To reset the rainfall accumulations, select Options in the Restart area.

The Hydromet option is then selected, followed by the Activate button (see Fig. 5-111). The Hydromet initialization will reset the Storm Total Precipitation product, but will not reset the database used to build the User Selectable Precipitation product.

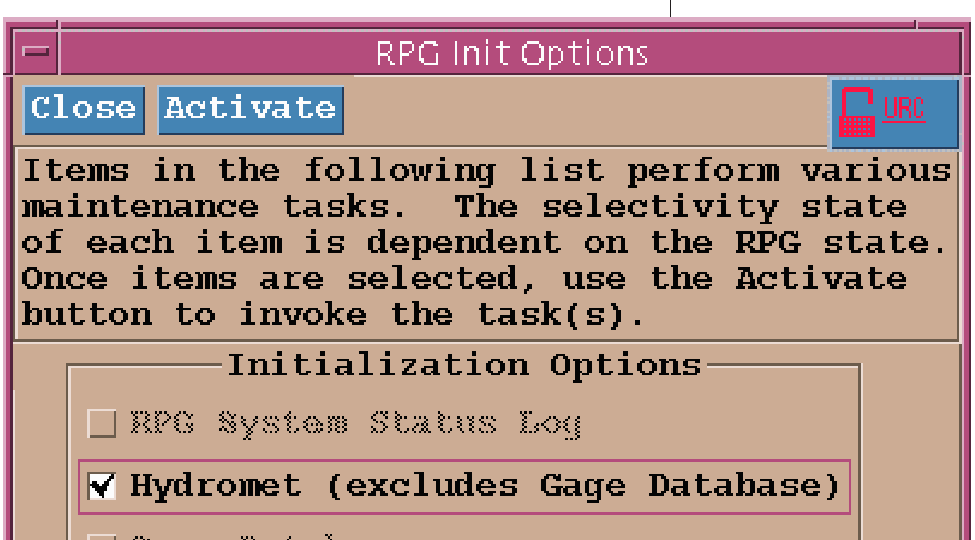


Figure 5-111. RPG Init Options window. After providing the URC password, select Hydromet, then Activate.

Storm Total Precipitation Limitations

1. **Can display precipitation over extended periods of time - may need to be manually reset to zero** (See RPG Build 6 Training for how to do this).
2. **Could include missing data without the knowledge of the operator.**

Storm Total Precipitation Applications (Strengths)

1. **Monitor total precipitation accumulation.**
2. **Estimate ground saturation and/or total basin runoff.**
3. **Post storm analysis.**
4. **Time lapse for tracking motion of storms.**

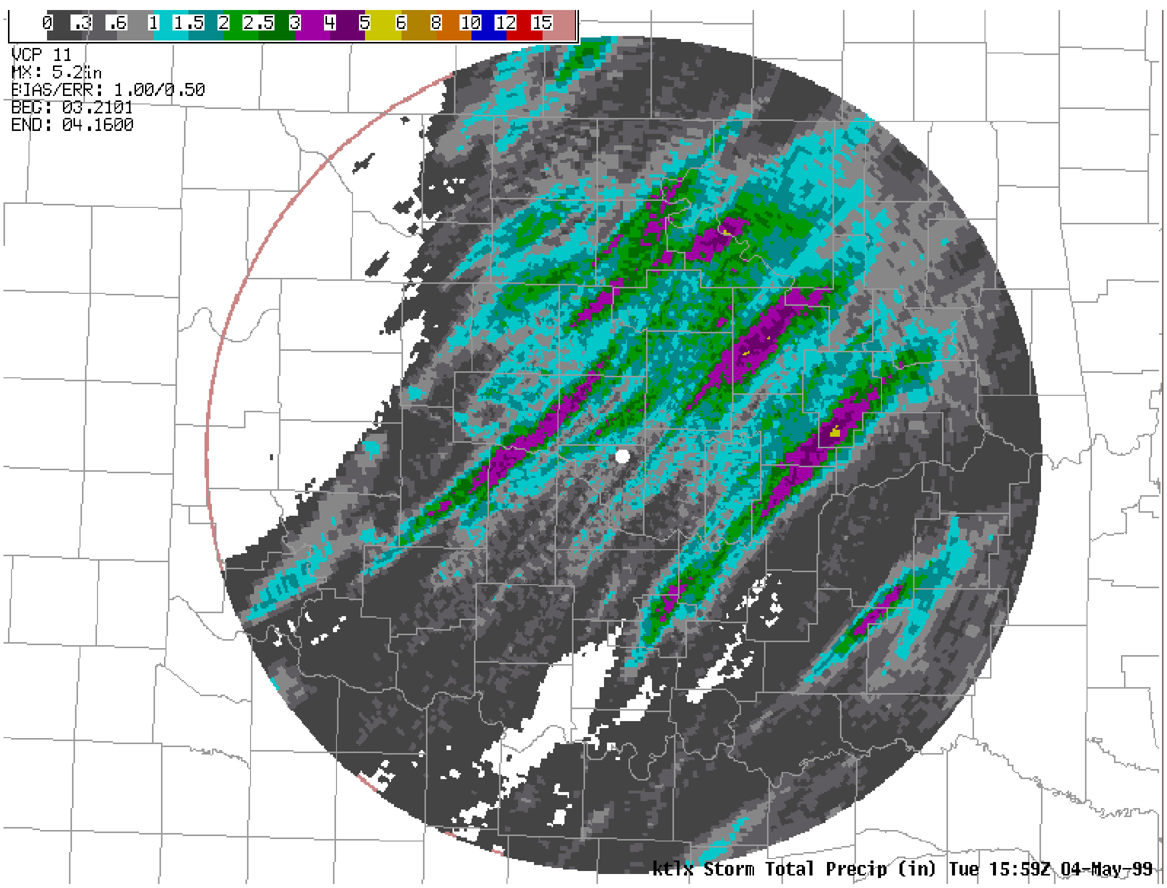


Figure 5-112. Storm Total Precipitation

User Selectable Precipitation

USP product legend description: (Fig. 5-113)

- RPG ID: kxxx
- PRODUCT NAME: User Def Total Precip
- UNITS: (in)
- DATE: Day of week, time, and date **in UTC**

USP product annotations:

- VCP: 11, 12, 21, 121, 31 or 32

Additional USP product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 1.1nm x 1 degree
- DATA LEVELS: 16 data levels available, OHP/THP data levels or STP data levels used

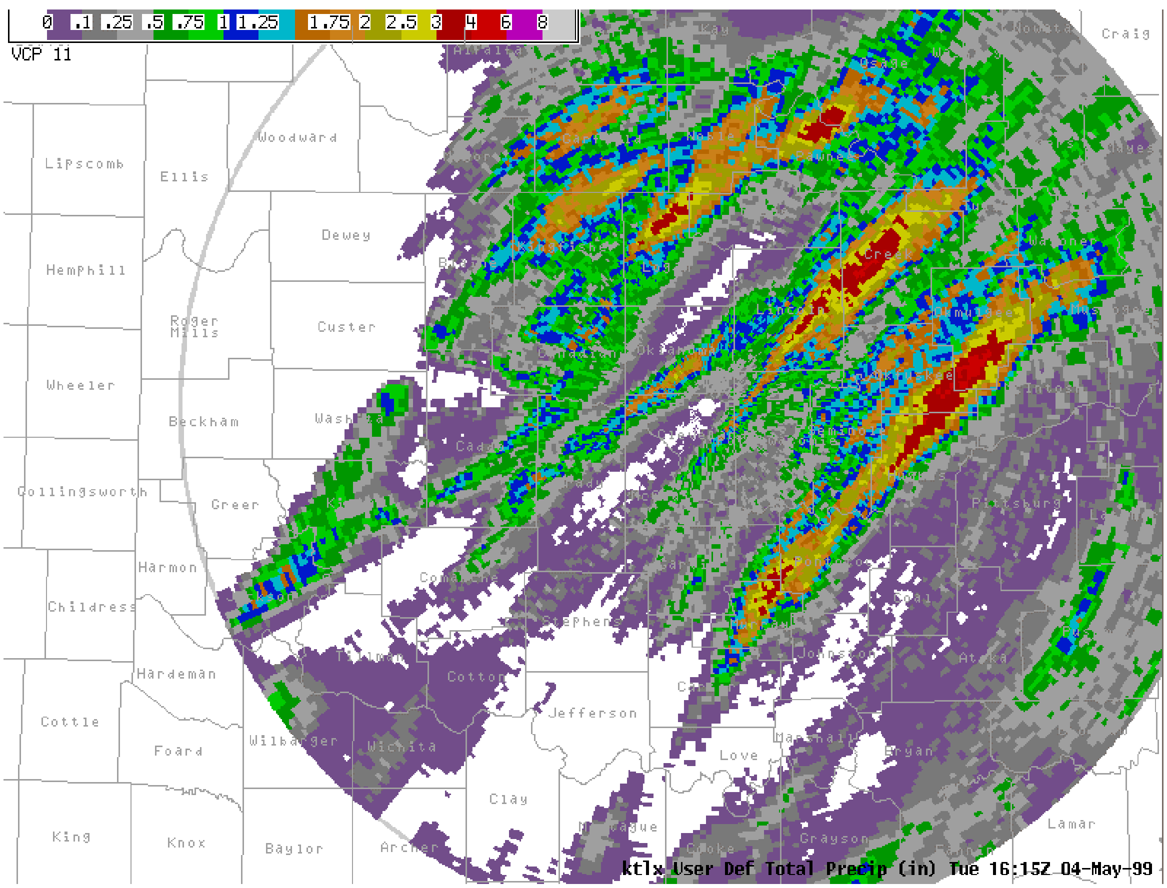


Figure 5-113. User Selectable Precipitation

dependent on the magnitude of accumulations.

Displays precipitation accumulations for a user specified period of time using top of the hour accumulations. The past 30 hours of top of the hour accumulations are available.

User selects duration (up to 24 hours) and end time (see Fig. 5-114).

Default USP generated for 24 hours ending at 12Z.

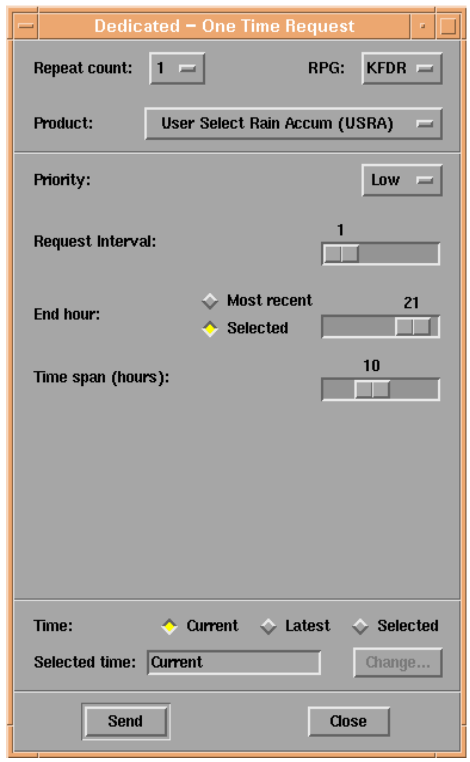


Figure 5-114. One Time Request

User Selectable Precipitation - Limitations

1. **USP accumulations are updated only at the top of the hour.**
2. **May contain missing data.** At least two thirds of the specified hourly accumulations must be available for product generation.

User Selectable Precipitation - Applications (Strengths)

1. **Flexible time interval to meet varying weather situations.**
2. **In addition to the 24 hour default USP, any others generated for dedicated users are available by OTR to dial-up users.**

One Hour Digital Precipitation Array (DPA)

DPA product characteristics:

- RANGE: 124 nm
- RESOLUTION: 2.2nm x 2.2nm (cartesian grid)
- DATA LEVELS: 256 data levels with a range of 0.00 to 12.70 inches in multiples of 0.05 inch.
- ACCUMULATION: Scan-to-scan accumulation with moving one hour of accumulation (similar to the OHP).

One Hour Digital Precipitation Array Limitations

1. **Low resolution (2.2nm x 2.2nm)**
2. **Not displayed in AWIPS**

One Hour Digital Precipitation Array Applications (Strengths)

1. **Used by the RFCs to generate precipitation input for the NWS River Forecast System (NWSRFS) and the AWIPS Multi-sensor Precipitation Estimator (MPE) bias calculation**
2. **The rectangular grid allows for mosaicking the numerous WSR-88Ds within the RFCs area of responsibility**

Supplemental Precipitation Data (SPD)

Supplemental Precipitation Data (SPD) product characteristics:

- Alphanumeric product (see Fig. 5-115 on page 5-184)
- Product requested via RPS list or One Time Request (OTR). The SPD is on the national RPS list for NWS sites, but will need to be requested from DoD radars

- Displayed using the command WSRSPDXXX.
- Generated each volume scan
- Contains information from the Precipitation Processing Subsystem including:
  - •• current bias value and whether it is applied,
  - •• information on gage-radar pairs,
  - •• information on the number of blockage bins,
  - •• percent of the hybrid scan bins filled, and
  - •• other output from the PPS.

Supplemental Precipitation Data Limitation

1. Lack of explanation for data values. Requires knowledge of PPS for interpretation.

Supplemental Precipitation Data (SPD) Application (Strength)

1. Only place to find detailed information on attributes of the PPS.

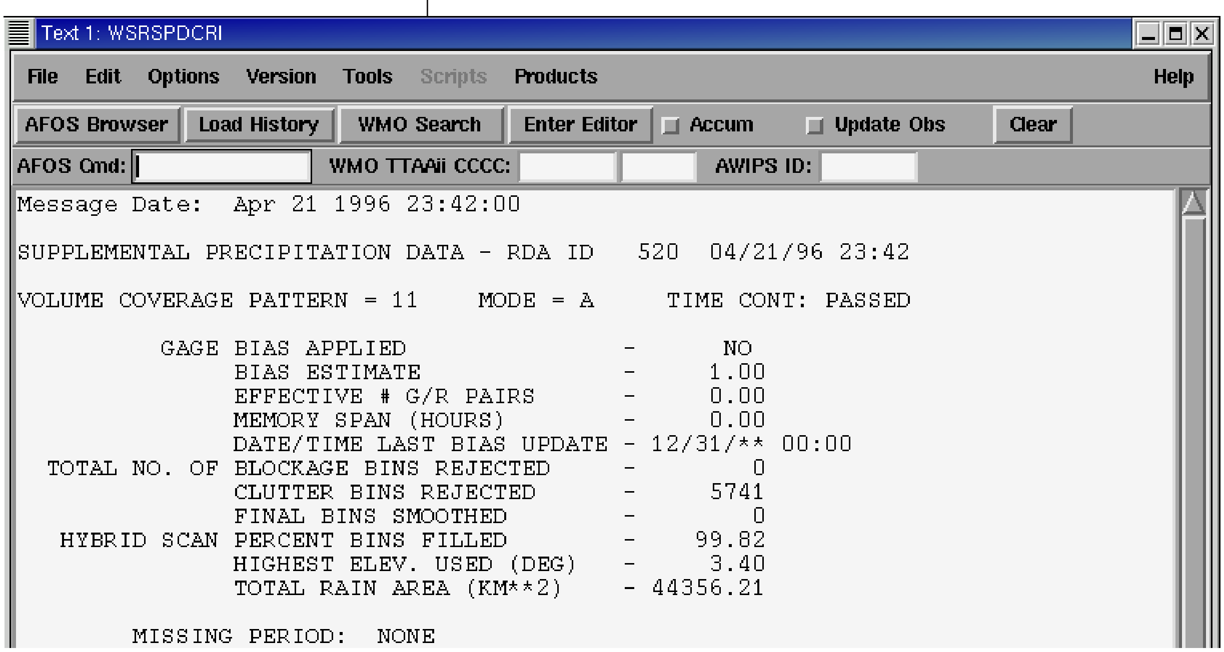


Figure 5-115. Supplemental Precipitation Data (SPD) product.

Precipitation Data Levels

Data levels on the One Hour, Three Hour, and Storm Total Precipitation products may be edited at the RPG HCI in accordance with policies set forth by your local Unit Radar Committee.

Why modify Precipitation Data Levels?

Data level changes depend on the location of the radar, topography and weather in the area of concern. For example, data levels in the Southwestern U.S. may need more detail in the lower end of the scale than areas along the Gulf Coast.

One/Three Hour Precipitation Products

The One/Three Hour Precipitation product has 16 accumulation data levels corresponding to each of the 16 color codes represented on the product.

The first data level is non-modifiable and has the acronym ND (No Data) for areas with no accumulation or areas outside the product coverage area.

The second data level is also non-modifiable and is given a value of > 0.00. This is color code 2 and displays regions with accumulations greater than zero but less than the level set for code 3.

The remaining levels, codes 3 to 16, are modifiable by the operator and range from 0.05 through 12.70 inches in multiples of 0.05 inch.

Editing OHP/THP Data Levels at RPG HCI

Click on User - Products - Selectable Parameters - OHP/THP Data Levels (See Fig. 5-116.)

Storm Total Precipitation Product

The Storm Total Precipitation product also has 16 data levels and is modified the same as the One/Three Hour product. The only difference is the range of the data levels.

Once again levels 1 and 2 are non-modifiable. Levels 3 to 16 are modifiable and range from 0.1 through 25.4 inches in multiples of 0.1 inch.

Editing STP Data Levels at RPG HCI

Click on User - Products - Selectable Parameters STP Data Levels (See Fig. 5-117.).

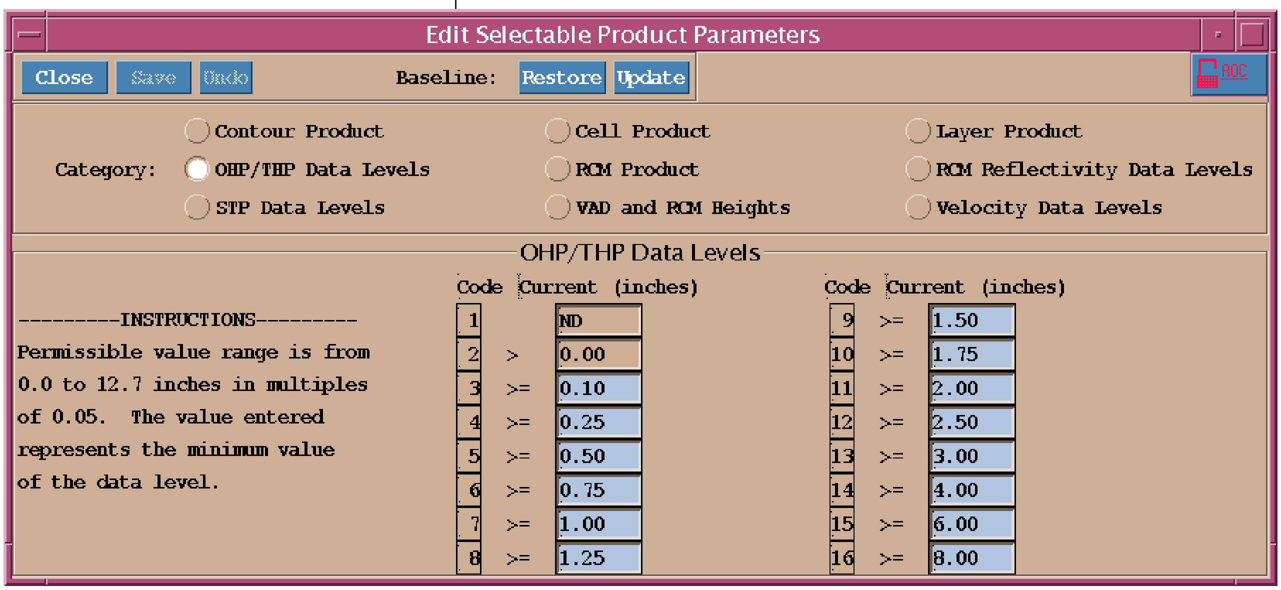


Figure 5-116. Edit screen for the OHP/THP product data levels at the RPG HCI.

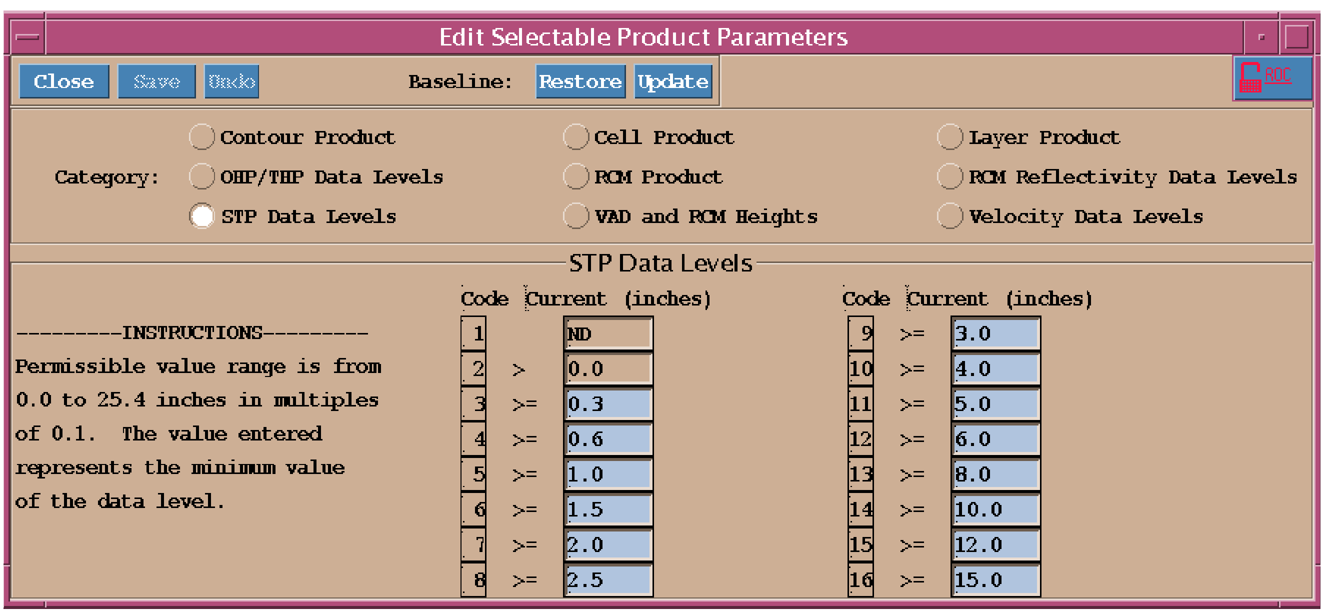


Figure 5-117. Edit screen for the Storm Total Precipitation product data levels on the RPG HCI.

Missing Data Summary

Recall from Topic 3 Lesson 6 *Precipitation Estimation* that if radar outages exceed 30 minutes that data is flagged as missing. Missing data is handled differently in different radar products.

- OHP is not generated
- THP is not generated until 2 top-of-the-hour accumulations (zero or non-zero) are available. This product may include missing data.
- USP is not generated unless 2/3 of the requested hour accumulations are computed. Missing data periods are listed on the USP attribute table
- STP will be generated even though data are missing with no indication on the product.

Interim Summary

One Hour Precipitation (OHP)

The One Hour Precipitation (OHP) product is a 16 data level product that displays accumulations for the past hour updated every volume scan (moving one hour window).

Three Hour Precipitation (THP)

The Three Hour Precipitation (THP) product is a 16 data level product that displays accumulations for a three hour period using three top-of-the-hour accumulations. The product is only updated once per hour.

Storm Total Precipitation (STP)

The Storm Total Precipitation (STP) product is a 16 data level product that displays accumulations from the first volume scan precipitation is detected, and is updated every volume scan. The STP is reset to zero after one hour of no precipitation as determined by EPRE, or when reset at the RPG HCI.

User Selectable Precipitation (USP)

The User Selectable Precipitation (USP) product is a 16 data level product that displays top-of-the-hour accumulations for a user selectable duration (up to 24 hours). The start and end hour must fall within the past 30 hours.

One Hour Digital Precipitation Array (DPA)

The One Hour Digital Precipitation Array (DPA) product is a 256 data level product with accumulations in a 2.2nm x 2.2nm grid. This product is used by the RFCs.

Supplemental Precipitation Data (SPD)

The Supplemental Precipitation Data (SPD) product is an alphanumeric product that contains both adaptable parameter settings and output from the Precipitation Processing Subsystem (PPS).

8/05

SUMMARY
OF
LIMITATIONS and APPLICATIONS (STRENGTHS)

These are from those found in the student guide and are provided here for your convenience.

I. Base Products

Base Reflectivity (Z)

Limitations

1. Ground Returns. Residual clutter and ground returns from superrefraction may contaminate products.
2. Beam Blockage. Beam blocking is possible especially on lower elevation angles.
3. Resolution versus range. Beam broadening leads to poor resolution at longer ranges.
4. Effects of earth curvature. Beam centerline increases in altitude with range.
5. Effects of discrete elevation sampling. Echoes may be poorly sampled by the VCP in use depending on range and echo geometry.
6. Cone of silence. Data are unavailable for higher altitudes close to the RDA.
7. Chaff. Chaff may cause large areas of non-meteorological echoes.

Applications (Strengths)

1. Observe precipitation intensity, movement, and trends.
2. Determine significant storm structure features.
3. Determine location and motion of fronts and other boundaries.
4. Locate and identify the melting level.
5. Identify non-meteorological phenomena.

Base Velocity (V)

Limitations

1. Range folding may obscure data.
2. Improper dealiasing may display erroneous velocity values.

Applications (Strengths)

1. Estimate the magnitude of radial velocities.
2. Determine radial velocity patterns to infer atmospheric structure.
3. Determine radial velocity patters to infer storm structure.
4. Aid in creating, adjusting, or updating hodographs.

Base Spectrum Width (SW)

Limitations

1. Range folding may obscure data.
2. Movement of ground clutter (cars, blowing leaves, etc) may result in high spectrum width values.
3. System noise may lead to erratic values.
4. Large amount of transmission time is required.

Applications (Strengths)

1. Evaluate the reliability of Base Mean Radial Velocity products.
2. Locate suspected areas of turbulence and shear regions.

II. Storm Related Derived Products

Storm Track Information Product (STI)

Limitations

1. Errors may occur in the identification of cells and the calculation of cell attributes when cells are in close proximity.
2. Large errors may occur in the attributes of cells close to the RDA, especially in VCP 21/121.
   Discussion: Recall that there are large gaps between elevation angles at higher slices in VCP 21/121. Calculations of Cell-based VIL, Cell Base, Cell Top, Height of Maximum Reflectivity, etc. can all be adversely affected by what the radar is **not** sampling in these gaps.
3. Unrepresentative movements are possible due to propagational effects.
   Discussion: Due to development or dissipation, the high reflectivity cores change location within an identified cell from one volume scan to the next, resulting in false representation of the movement of the cell.
4. Forecast positions of curving cells are displayed as a straight line.
   Discussion: Since position forecasts are always in a straight line, the past tracks of a cell should be taken into account when using the position forecast of a curving cell.

Applications (Strengths)

1. The product works best with well-defined widely separated cells.
   Discussion: Forecast positions in this case can be used in the timing of storms in warnings and nowcasts. Keep in mind that the forecast position is that of the centroid, and that adjustments should be made if the user is trying to time the leading edge of the echo or the location of a tornadic circulation.
2. A large number of past tracks, and/or four forecast positions signifies a more reliable cell movement.
   Discussion: Uneven spacing between past tracks, fewer than four forecast positions, and/or re-identification of cells indicate less reliable forecast positions.
3. The STI product is useful as an overlay on volume products, but not limited to volume products.
   Discussion: Because the product and overlay are produced at the end of the volume scan, it makes it more convenient to display on top of other volume products such as VIL and CR.
4. Cell motion is used in Storm Relative Velocity products (SRM)
   Discussion: This is what allows us to quickly view a storm relative velocity product to check for circulations. Note that any errors made in the tracking process will also be passed along to the storm relative products.
5. Cell attributes are critical inputs to the Hail Index product and SCAN.
   Discussion: Proper cell identification will improve the value of both the Hail Index Product and the Cell Trends Display.

Hail Index Product (HI)

Limitations

1. The Hail Detection Algorithm needs as input, accurate and timely measurements of the MSL altitudes for the 0^0 C and -20^0 C levels.
   Discussion: Failure to update this information will degrade the algorithm's performance. Operators will also want to note this information on products which they get via dial-out.
2. Values of POH, POSH, and MEHS will fluctuate at close ranges, especially in VCP 21,121 due to gaps in coverage at higher elevation slices.
   Discussion: As a cell 50,000 feet at 80 nm moves toward the radar, the 6 degree elevation slice samples the storm at lower altitudes. Therefore POH, POSH, and MEHS would all lower. As the same cell starts moves to less than 50 nm from the radar the 9.9 degree slice begins to sample the cell at 50,000 feet, and the POH, POSH, MEHS suddenly jump not because the cell has changed, just due to how the cell is being sampled.

3. The values for POH, POSH, and MEHS may fluctuate at longer ranges from the radar due to the limited number of slices through the cell.
   Discussion: The altitude is calculated using the center-point of the beam. There can be over 10,000 feet difference in the center-points on adjacent slices at ranges over 90 nm. This can cause estimates to change erratically.
4. The maximum hail processing range is 124nm. For cells beyond 124 nm, hail will be identified as UNKNOWN.
   Discussion: UNKNOWN is considered a lower priority than zero in attribute tables. This means a severe cell at greater than 124nm from the radar may be listed after an insignificant storm within 124nm of the radar on the Hail Attribute Table and the Composite Reflectivity Combined Attribute Table.
5. **POSH** and **MEHS** have tended to overestimate the chances and size of hail in weak wind and tropical environments and mountainous locations.
   Discussion: The accuracy of the hail estimates partially depends upon the accuracy of cell (component) information. **MEHS** is an estimation of the largest hail in the cell, and often times, most of the hail from a cell is smaller. The operator has to keep in mind that the MEHS should only be used as a guide. Storm spotters and other operational means should be integrated into the warning decision.

Application (Strength)

1. The Hail Detection Algorithm has shown a very high probability of detection in cells that contain severe hail, especially greater than one inch diameter hail.
   Discussion: A **POSH** of 50% or greater has shown skill (CSI) as a warning threshold.

III. Reflectivity Derived Products

Vertically Integrated Liquid (VIL)

Limitations

1. VIL values are biased by drop size.
   Discussion: Recall that the VIL equation uses Z (reflectivity), and that $Z = nD^6$ where D is the drop size (from the radar equation).
2. Grid VIL values will differ from Cell-Based VIL values.
   Discussion: Grid VIL values (which is what the VIL product is displaying) are derived for each 2.2 x 2.2 nm grid box where there is any data at any elevation, regardless of whether or not a “cell” has been identified by the SCIT algorithm. On the other hand, Cell-Based VILs require a storm cell to be identified first. Then using the components included in this cell definition, a single VIL for that storm cell is calculated.
3. Values for warnings may change daily and across the warning area. Threshold values are airmass dependant.
   Discussion: Different airmasses will require different warning thresholds!
4. Values within 20 nm of radar are underestimated.
   Discussion: Storms moving into the cone of silence will appear to diminish as less and less of the storm is sampled. They will then appear to strengthen as they move out.
5. VIL values for a strongly tilted or a fast moving storm will be **lower** than if the storm was vertical or moving slower.
   Discussion: In this case, the upper portion of the storm may extend into another grid box. It is here that a Cell-Based VIL may be more useful.
6. May be contaminated by non-precipitation echoes.
   Discussion: If non-precipitation echoes or AP returns exist, they will end up in the reflectivity data, which in turn will cause these data to be used in the VIL calculation.
7. More VIL fluctuation with VCPs 21 and 121 than in VCPs 11 or 12.

Discussion: There are fewer gaps in VCP 11 and 12, mainly within 60 nm of the radar. Forecasters should keep this in mind when using any one volume scan to infer a trend, especially in VCP 21 or 121.

8. Values at distant ranges (> 110 nm) are occasionally **unreliable.**
   Discussion: In the VIL calculation, the reflectivity value at 0.5^0 is integrated down to the ground. At distant ranges the beam may be cutting through the highly reflective hail cores in the mid levels of a storm, producing an overestimation of VIL. Or, in smaller storms the beam may be overshooting the core entirely, resulting in an underestimation.

Applications (Strengths)

1. Locate storms with more significant reflectivity cores.
   Discussion: High VIL values correspond to deep areas of high reflectivity indicative of strong updrafts. Keep in mind however that storms with shear which is significant may not necessarily have higher VILs.
2. Useful for distinguishing storms with large hail once threshold values have been established.
   Discussion: Once a threshold is established (by real-time comparison with reflectivity structures and spotter reports) forecasters can infer that storms in the same environment will likely have the same thresholds. Issues regarding the impacts of sampling should always be considered, however.
3. Persistent high VIL values are often associated with supercells.
   Discussion: Supercells with extensive reflectivity cores will exhibit relatively large VILs (considerably larger than the “warning threshold”). Keep in mind that this will not be the case for mini supercells, or LP supercells.
4. Rapid decrease in VIL values may signify onset of wind damage.
   Discussion: This is similar to the collapse of the storm top and the correlation of this with wind damage. However, you should use caution with this technique. Sampling considerations, especially in VCP 21 and 121 close to the radar, or the impact of the cone of silence in any VCP, may cause an apparent, but not actual, drop in VIL.

Digital (High Resolution or 8-bit) VIL (DVL)

Limitations

1. Higher resolution and lack of truncation produces different values when compared to VIL.
2. Fast moving or highly tilted storms will produce lower DVL values than if the same storm was vertical or slow moving.
3. 80 kg/m^2 is commonly reached due to lack of truncation of high reflectivities.

Applications (Strengths)

1. Displays low reflectivity features (snow bands, gust fronts, smoke plumes, etc)
2. Ground clutter has less impact on DVL than other volume products.

Reflectivity Cross Section (RCS)

Limitations

1. Cross section placement may hamper evaluation of storm structure.
   Discussion: Depending on the cross section placement, different aspects of the storm can be evaluated.
2. Echo tops and bases are truncated with no vertical extrapolation on the highest or lowest elevation angles.
   Discussion: This will be more of a problem in VCP 21 close to the radar since there are more gaps to be interpolated across. In addition, echo tops which actually terminate between beam center points on successive elevation angles will be underestimated. Bases on storms at distant ranges will be overestimated due to the effects of earth’s curvature on sampling.
3. Height vs. range exaggeration.
   Discussion: This has always been the case, with even the RHI presentation. This is because the vertical extent of the product is 70,000 ft, while the maximum range is 124 nm.

4. Small features may be enlarged or missed due to interpolation.
   Discussion: Depending on where the elevation slices cut the storm, you could over exaggerate a reflectivity core, or totally miss a BWER. Once again, this will present more of a problem in VCP 21 within around 60 nm of the RDA due to more gaps.
5. Presentation of product dependent upon VCP.
   Discussion: Generally the product will be more coarse and blocky looking with VCPs 21 and 121 than VCPs 11 or 12. Once again, this is due to more gaps within 60 nm of the radar in VCPs 21 and 121.
6. Fast moving storms may appear to be strongly tilted.
   Discussion: What appears to be an echo overhang in this cross section may actually be an artifact of VCP sampling on a fast moving storm. This is due to the time needed to complete a volume scan and the fact that the storm doesn't hold still during that time. Once again, a little more impact with VCPs 21 and 121.

Applications (Strengths)

1. Detect the vertical extent of clouds/insects/smoke plumes.
   Discussion: Regardless of the phenomenon being sampled, the depth or vertical extent can be estimated with a cross section.
2. Verify existence of a bright band.
   Discussion: The bright band, a representation of the freezing/melting layer, is depicted on a Base Reflectivity product as a ring of higher reflectivities. On a cross section, it will appear as a band of higher reflectivities.
3. Estimate height of higher dBZ's.
   Discussion: Placement is critical when attempting to estimate dBZ heights. Using the VIL ,Composite Reflectivity, or a 4panel Reflectivity display may help with placement of the cross section through the reflectivity core of the storm.
4. Evaluate storm structure features.
   Discussion: Again, placement is critical in order to see features such as BWER's, WER's, the presence of a TBSS, low echo centroids, storm tilt, etc. It may be useful to use a 4-panel reflectivity presentation with linked cursors to find a best fit line that bisects the BWER at several elevations.
5. Estimate echo tops.
   Discussion: While this product will display reflectivities down to 5 dBZ in precipitation mode, echo tops can generally be correlated with the height of the 20 dBZ returns. Using the Echo Top Product as an aid for placing the cross section line may be helpful.
6. Monitor the formation/dissipation of precipitation events.
   Discussion: This would be helpful with high based convection or with convection which initially develops aloft.

Composite Reflectivity (CZ)

Limitations

1. Low level reflectivity signatures are obscured.
   Discussion: Because the algorithm uses the maximum reflectivity for each grid box from any elevation angle, many characteristic signatures will be masked. The CZ product will show features, such as hook echos, at the low slice with the echo overhang attained from the higher slice. DO NOT use the CZ product by itself to diagnose the presence of hook echoes, BWERs, WERs, Inflow Notches, boundaries, etc.
2. Height of reflectivity is unknown.
   Discussion: One grid box may be from 0.5^0 , while the grid box next to it may be from 10.0^0.
3. Echo aloft can't be discriminated from precipitation reaching the surface.
   Discussion: What looks like precipitation, my actually be cloud layers at 15kft! Be especially careful when using the CZ product to infer the location of snow or very light rain, as much of it may in fact be aloft.
4. Non-precipitation echoes may contaminate product.

Discussion: If Non-precipitation echoes or ground clutter are present in the Base Reflectivity data they will make their way into the CZ product.

Applications (Strengths)

1. Reveals highest reflectivity in all echoes.
   Discussion: This is a quick way to check which storms have the highest reflectivity present.
2. Determine storm structure features & intensity trends in storms. (When compared with base products).
   Discussion: While a CZ product BY ITSELF can not be used to determine storm structure, it can be very useful when used in conjunction with other products. By displaying a 0.5^0 reflectivity product on one screen and a CZ product on the other, you can (with cursors linked) assess the location and extent of the echo overhang.
3. Generate cross sections through maximum reflectivity knowing the inflow side of storm.
   Discussion: Once you see a core of 65 dBZ, you probably want to know if it's one pixel, shallow, or has great vertical extent. You can use the CZ product to help place the line for the RCS and determine these attributes.
4. Combined Attribute Table is available.
   Discussion: It is a quick way to scan output from several algorithms without having to check through several products.

Layer Composite Reflectivity Maximum (LRM)

Limitations

1. Mid & Low layer products will use few elevation angles at long distances.
   Discussion: At long ranges where the 0.5^0 slice is at a considerable altitude, there may be only 1 or 2 slices used to compute the max value. At closer ranges, there will be data from several slices.
2. Mid and High level products are ineffective at close range due to the cone of silence.
   Discussion: There will be a hole around the radar location where the cone of silence precludes data from being used for especially the mid and high level product. That does NOT mean echo does not exist over the radar site!
3. Low layer product susceptible to non-precipitation echoes.
   Discussion: Generally speaking, the low layer is the one susceptible to ground clutter returns (anything that makes it into base reflectivity data, will make it into the LRM products). The amount of contamination will depend on the altitude used for the base of the LRM product. Often, the mid and high layer products will not have this problems except on rare occasions when the returns have significant vertical extent.

Applications (Strengths)

1. Mid-High layer products can be used to estimate the height of higher reflectivities.
   Discussion: Monitoring the LRM products may assist forecasters in getting a jump on the height of higher reflectivity cores. For instance, raising the lower layer boundary to the melting level may provide the forecaster valuable information on the height and intensity of developing pulse-type storms by using the LRM-Low product.
2. Comparison of Base Reflectivity and Mid or High Layer Composite Reflectivity Maximum product may aid in determining a storm's intensity trend.
   Discussion: If the lowest slice Base Reflectivity and the corresponding Mid layer LRM shows significant echoes in the same vicinity, you could infer that the storm is still dominated by updraft with almost all of the echo aloft. In pulse type thunderstorms, this may be the only lead time you get for warning purposes.
3. Use of the mid level product can help differentiate ground clutter from precipitation echoes.
   Discussion: Clutter which is evident on the lower slices of a Base Reflectivity,will most of the time completely disappears on the LRM-Mid Layer product. Use of the LRM-Low Layer product for this purpose would require raising the height definition to above the ground clutter.

User Selectable Layer Reflectivity Maximum (ULR)

Limitations

1. Height of data within selected layer is unavailable.
2. Shallow layers will often have concentric circles (stepped appearance) due to sampling (limited elevation angles through layer).

Applications (Strengths)

1. Layer can be selected to meet user needs.
2. Has higher resolution and more data levels than LRM products.
3. Can be used to locate bright band.
4. Help locate storms with significant hail threat by looking at a layer centered on $–20^{0}$C.

Enhanced Echo Tops (EET)

Limitations

1. Circular stair-stepped appearance will often be evident due to use of discrete elevation sampling.
2. Side lobes may result in overestimated tops.
3. Tops will be underestimated close to the radar due to the cone of silence (coded as “topped”).

Applications (Strengths)

1. Quick estimation of the most intense convection (higher echo tops).
2. Assist in differentiating non-precipitation echoes from real storms.
3. Aids in identification of storm structure features such as tilt, updraft flank, max top over strong low level reflectivity gradient, etc.
4. May detect mid-level echoes before low-level echoes are detected.

IV. Velocity Derived Products

8-Bit Storm-Relative Mean Radial Velocity Map (SRM)

Limitations

1. Care must be taken to ensure a representative storm motion is being produced by the default motion setting chosen.
2. It is more difficult to determine actual ground-relative winds.
3. The 8-bit Base Velocity products used by AWIPS to produce the 8-bit SRM are large and can produce narrowband loadshedding unless a LAN-to-LAN connection is used.

Strengths/ Applications

1. High detail both spatially and in data magnitude can provide improved detection of TVSs, Mesocyclones, Microbursts, Boundaries.
2. Same data levels and color scales can be used for both Clear Air Mode and Precipitation Mode VCPs.
3. High Storm Relative Velocities (up to 248 kts) are displayable and viewable on cursor readout sampling.
4. Very useful for examining the velocity structure of fast moving storms (>10 knots).

4-Bit SRM

Limitations and Applications (Strengths)

Essentially the same as for the 8-bit products, only resolution is less and the displayable magnitudes of the velocity values are less, both making the 8-bit SRM more useful. However the 4-bit product file sizes are much smaller, and therefore require less bandwidth, and do not necessarily need user input for storm motion.

Velocity Cross Section (VCS)

Limitations

1. Doppler velocities are relative to the RDA.
   Discussion: As stressed in Velocity Interpretation, you must always know where the phenomenon is in relation to the RDA. It is recommended that you display the Current Cross Section Overlay on one screen (left) and the corresponding cross section on the opposite screen. Attempt to interpret a velocity cross section without knowing where the RDA is relative to it, is impossible!
2. Height exaggerated vs range.
   Discussion: With the grid used, the height can be up to 70Kft with the range up to 124nm. This is the same limitation observed in the RCS product that makes features look skinny and taller than they look out your window.
3. Interpolation may enlarge or miss features.
   Discussion: Just as with the RCS product, gaps in the VCP will result in interpolation which may smooth through or enlarge a particular feature.
4. Storm-relative cross section is NOT available.
   Discussion: This may make it difficult to interpret signatures in especially fast moving storms.
5. Storm top divergence estimates are limited due to radar viewing angle and data thresholds.
   Discussion: Difficult to determine hail larger than golf ball size using NSSL criteria unless both maxima listed on the top of the grid are close to the storm summit.. As always, the ability to see features with the cross section products is highly dependent upon placement of the cross section.

Applications (Strengths)

1. Aid in determining storm structure features.
   Discussion: These features include:
   a. Inferring location of **updraft/downdraft interface** - as seen on a VCS taken <u>down the radial</u>.
   b. Strength of **storm top divergence** - When scanning down radial, we are looking for convergence at low levels, updraft/downdraft interface, and finally divergence at storm summit.
   c. **Depth of mesocyclones** - For this you want a VCS <u>perpendicular to the radial</u> through the mesocyclone.
2. Has proven very valuable for kinematic insights in a research setting.
   Discussion: You may have figured it out by now, but Velocity Cross Sections take some practice at interpreting. That (plus the limitations listed above) will probably limit their use during real time. They are however extremely useful for gaining insight to the kinematic workings of the thunderstorm in a research setting.

Velocity Azimuth Display (VAD)

Limitations

1. Needs sufficient data points.
   Discussion: Clear, cold, dry air often lacks scatterers. No sine wave will be plotted unless there are at least 25 data points.
2. May be unreliable in disturbed environments.
   Discussion: The algorithm assumes horizontal uniformity of the wind field. Imagine a cold front lying across the RDA. You look to the North, the winds are blowing toward the radar. You look toward the South ahead of the front, winds are also blowing toward the radar. The algorithm will have a hard time finding an “average” wind across the area under these circumstances! The wind estimate it gives you (if indeed it gives you one at all) will NOT be very useful.
3. Available for pre-established altitudes only.
   Discussion: The altitudes are set at the RPG HCI. If you want to see winds at any other altitudes, you must change them there (URC level of change authority).

4. Large flocks of migrating birds may produce anomalous wind data.
   Discussion: The averaging of the motion of birds in conjunction with the motion of the wind, can lead to erroneous wind data. Birds can cause the speed to be off by several knots and the direction to be off by several degrees. Typical symptoms include an “explosion” of reflectivity returns in a “butterfly” pattern centered on the RDA just after sunset.

Applications (Strengths)

1. Winds available in clear air or precipitation mode.
   Discussion: Generally speaking, the wind estimates will be slightly better in clear air mode since the radar antenna rotation is slower. This may on some occasions mean you will get winds through a deeper layer as well.
2. Does not require 360 degrees of data.
   Discussion: The algorithm only requires 25 data points (that’s a sample from 25 degrees of azimuth) and they don’t have to be contiguous. The “Beginning” and “Ending” azimuth range is set at the ORPG HCI and is under URC level of change authority.
3. Check missing or suspicious wind data on the VWP.
   Discussion: This is probably the primary reason many operators choose to look at the VAD. When you see “ND” plotted on the VAD Wind Profile, you can go the VAD at that altitude and see what happened.
4. Update Environmental Winds Table.
   Discussion: The VAD winds are fed into the Environmental Winds Table for use in the velocity dealiasing algorithm. This helps minimize erroneous winds due to dealiasing errors.

VAD Wind Profile (VWP)

Limitations

1. Measurable returns needed - for each altitude, at least 25 data points are required on the VAD for a sine wave to be plotted. If one is not plotted, the wind will not be calculated at that altitude.
   Discussion: In what instance might you think scatterers would be few and far between? Generally, the dryer and more pristine the atmosphere, the fewer the number of scatterers. This would likely occur with the intrusion of a clear, dry arctic airmass. In addition very high altitudes which are free of clouds will seldom have enough scatterers to produce reflectivity return.
2. Winds are not encoded if RMS error or symmetry thresholds are exceeded.
   Discussion: If the points don’t fit the sine curve well enough (RMS exceeds 9.7 kts), or if the winds are too convergent or divergent across the RDA (symmetry exceeds 13.6 kts), then “ND” will be plotted at that altitude of the VWP.
3. Generally only representative of winds within 20 nm of the RDA.
   Discussion: This is a wind estimate, averaged around 360^0 of the RDA. It is attempted to be taken at the same range (default slant range) at all elevations. While this gives a good estimate of a “profile” of the winds at the surface and aloft near the RDA, it tells you nothing about winds at much further ranges.
4. Difficult to read wind barbs when north wind barbs and south wind barbs are on successive altitudes.
   Discussion: When winds are due north or due south at adjacent altitudes, the barbs may tend to overwrite each other. Use of the Filter or Blink Functions may help.
5. Birds can produce anomalous wind patterns.
   Discussion: The usual scenario is an "explosion" of reflectivity coverage and strength as night migrating birds take off. Experts claim that a single Sea Gull can be detected at a range of 460 km. If it is critical to determine the true upper winds, the site should take a supplemental balloon sounding.

Applications (Strengths)
1. The VAD Wind Profile (VWP) may be of assistance in forecast and warning operations.
Discussion:
Severe Weather operations may benefit as backing or veering of the winds with time display changes in the environment.
Aviation operations will be assisted by evidence of wind shear. Low level wind shear may be more visible on VWP than Profilers. **Hydrology** and **Forecasting** may benefit from indications of the change in the depth of cold air with time, etc. In addition, since sufficient scatterers are often more prevalent in and near clouds, the VWP may be used in estimating cloud tops and bases, and the change of those bases and tops as the cloud layer approaches or recedes.
2. The VWP can be used to create/adjust hodographs.
Discussion: Remember to use the VWP of the radar whose environment most closely resembles that of the storms being sampled.
3. Future development may include combining the Storm Tracking Algorithm and VAD Wind Profile to output helicity.
Discussion: The integration of data sets into one workstation will allow for this and other applications to be developed.

Mesocyclone Detection (MD) and Digital Mesocyclone Detection (DMD)

Limitations
1. Does not need 10,000 ft deep circulation. The algorithm only requires vertically linked 2D circulations.
2. The algorithm only detects cyclonic rotations.
3. Ident6ification is influenced by aspect ratio.
4. Improper dealiasing may generate false mesocyclones
5. Default setting are for large deep supercells. Changes to adaptable parameters are required for smaller circulations.
6. Numerous detections of circulations may require changes in adaptable parameters.

Applications (Strengths)
1. Identify mesocyclones. The operator must examining reflectivity, velocity or SRM to verify existence of mesocyclones.
2. Weak circulations are detected.
3. Adaptable parameter changes are available to adjust the output to fit the meteorological situation.
4. Tracking attempts to account for time continuity.

Tornadic Vortex Signature (TVS)

Limitations
1. Adaptable parameters need more research.
Discussion: Parameters which work well in one type of meteorological setting may not be as effective in other situations. More research on the results of various adaptable parameter settings is also needed.
2. High false alarm rates especially in squall lines and tropical cyclones.
Discussion: A high FAR with TDA may result in over-warning, or desensitizing forecasters.
3. Little research has been done to date relating the occurrence of tornadoes to Elevated TVSs.
Discussion: Forecasters should use ETVS output with caution until they develop a better understanding of its utility.

Applications (Strengths)
1. Algorithm searches for gate-to-gate shears.
   Discussion: The definition of an operator defined TVS is based on gate-to-gate shear associated with tornadic circulations. The algorithm attempts to follow this definition.
2. Multiple velocity-difference thresholds make it possible to isolate small regions of shear within broader regions.
   Discussion: In areas of broad shear, such as along a squall line, the higher velocity thresholds help to identify small scale circulations within high-shear zones, such as what you would find along the comma-head in a bow echo.
3. A distinction is made between different types of shears.
   Discussion: Information depicted about each feature includes whether or not it is a TVS or an ETVS as well as the relative strength and vertical depth of the feature. This information can be operationally significant when attempting to rank and sort through identified features.
4. Adaptable parameters allow for fine-tuning of algorithm output.
   Discussion: Through a number of parameter sets as well as individual adaptable parameters, operators can fine tune the output for their location and environment, as well as operator preference. As a result, it is more likely that operationally significant shear regions will be detected.

TVS Rapid Update (TRU)
Limitations
1. Classification as INC (increasing or PER (persistent) may be the result of sampling issues versus an actual change of the feature.
2. The TRU graphical attribute table and alphanumeric product contain attributes from both the previous and current volume scan. ^ indicates the attribute is from the current volume scan.
3. Feature matching ability is dependent on the motion supplied by the MDA (average motion of all MDA features). This motion could be very different than the TVS feature.

Applications (Strengths)
1. Intermediate Tornado Detection Algorithm (TDA) is available before end of volume scan.
2. TRU tracks features to develop time continuity.

V. Precipitation Algorithms and Products

Hybrid Scan Reflectivity (HSR)
Limitations
1. Ground clutter and AP is sometimes displayed on the HSR product.

Applications (Strengths)
1. View reflectivity used for precipitation products.
2. Assess the accuracy of the precipitation products.
3. Quickly search for inconsistencies in the data.
4. Assist operator in discriminating between precipitation returns and ground returns due to AP.

Digital Hybrid Scan Reflectivity (DHR)
Limitations
1. Large product size

Applications (Strengths)
1. High resolution (256 data levels) allows for innovative color tables.
2. High accuracy (0.5 dBZ)
3. Used in the generation of external products.
   - Flash flood Monitoring and Predicition (FFMP)
   - Jendrowski Scripts (multiple Z/R AWIPS Application)
   - Areal Mean Basis Estimated Rainfall (AMBER)

One Hour Precipitation (OHP)
Limitations
1. After extended outages, the first product will not be generated for 54 minutes.
2. For some events, viewing interval is too short.

Applications (Strengths)
1. Assess rainfall accumulations for flash flood watches, warnings, and statements.
2. Useful for nowcasts and special weather statements.
3. Time lapse can provide storm movement.
4. Can apply to other water management applications.

Three Hour Precipitation (THP)
Limitations
1. The product updated only once per hour.

Applications (Strengths)
1. The THP provides a longer viewing interval.
2. For very long duration events, it can be used with Storm Total Product for analysis.
3. The three-hour interval corresponds to timing of flash flood guidance values.

Storm Total Precipitation (STP)
Limitations
1. Can display precipitation over extended periods of time – may need to be manually reset to zero.
2. Could include missing data without the knowledge of the operator.

Applications (Strengths)
1. The product can be used to monitor total precipitation accumulation.
2. It provides a good estimate of ground saturation and/or total basin runoff.
3. The product is very useful for post storm analysis.
4. When used in a time lapse, it is useful for tracking the motion of storms.

User Selectable Precipitation (USP)
Limitations
1. USP accumulations are updated only at the top of the hour.
2. The product may contain missing data. At least two thirds of the specified hourly accumulations must be available for product generation.

Applications(Strengths)
1. The product provides a flexible time interval to meet varying weather situations.
2. In addition to the 24 hour default USP, any others generated for associated users are available as a one-time request to dial-up users.

One hour Digital Precipitation Array (DPA)

Limitations

1. Low resolution (2.2nm x 2.2nm)
2. Not displayed in AWIPS

Applications(Strengths)

1. Used by the RFCs to generate precipitation input for the NWS River Forecast System (NWSRFS) and the AWIPS Multisensor Precipitation Estimator (MPE) bias calculation.
2. The rectangular grid allows for mosaicking the numerous WSR-88Ds within the RFC's area of responsibility.

Supplemental Precipitation Data (SPD)

Limitations

1. Lack of explanation for data values. Requires knowledge of PPS for interpretation.

Applications (Strengths)

1. Only place to find detailed information on attributes of the PPS.

08/05

Review Exercises
Base Products

1. For Base Reflectivity products, which of the following is/are **Not** (a) limitation(s)?
   a) Residual clutter and ground returns
   b) Resolution vs range
   c) Range folding
   d) Effects of discrete elevation sampling
   e) Cone of silence

2. Which of these statements concerning 8-bit Reflectivity products is/are true?
   a) The 8-bit Reflectivity products are very useful in detecting boundaries
   b) The product should be used for identifying storm structure features such as WERs, BWERs, and hook echoes.
   c) The product comes in 8 or 16 data levels depending on settings at the RPG HCI.
   d) Several elevation cuts are needed for proper storm evaluation.

3. **True/False** Forest fires, chaff and other non-meteorological phenomena will be observed on the Base Products at times, but only while operating in VCPs 21 and 121.

4. To attempt mitigation of Range Folding the radar operator can:
   a) Adjust the PRF
   b) Invoke Clutter Suppression
   c) Select a higher elevation slice
   d) Switch to VCP 121
   e) All the above

5. Which of these statements concerning 8-bit Velocity products is **false**?
   a) Range folding may obscure data at times.
   b) The resolution of the 8-bit Velocity product is .13 nm resolution, with a range of 124nmi.
   c) Velocities will not be improperly dealiased, except around strong mesocyclones and TVSs.
   d**)** The product is useful in estimating ground relative wind speeds.

6. A bow echo is observed 35 nm west of the RDA and is moving east. You are investigating 8-bit Velocity products for a possible wind maximum that may produce surface straight line wind damage. However, range folding is observed on the 0.5 degree products. You are currently in VCP 11. Of the following, which is the best action to take to display reliable velocity data?
   a) Change the velocity data levels at the RPG HCI after gaining approval through the unit radar committee.
   b) Use a .54 nm Base Velocity product.
   c) Send a one-time request for a Base Spectrum Width product.
   d) Switch to VCP 12.
   e) Switch to VCP 121.

7. The Spectrum Width product can be used to:
   a) Evaluate the validity of the mean radial velocity estimates.
   b) Help locate boundaries
   c) Locate areas of suspected turbulence
   d) Detect chaff only when operating in VCP 12 and 121.
   e) Calculate rotational velocities in tornadic thunderstorms.

8. **True/False.** Areas of range folding on velocity products will also be range folded on Spectrum Width products.

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Review Exercises
Base Products
*****ANSWER KEY*****

1. For Base Reflectivity products, which of the following is/are **Not** (a) limitation(s)?
   a) Residual clutter and ground returns
   b) Resolution vs. range
   c) Range folding
   d) Effects of discrete elevation sampling
   e) Cone of silence

Answer: C. Range folding shows up on velocity and spectrum width products, not reflectivity.

2. Which of these statements concerning 8-bit Reflectivity products is/are true?
   a) The 8-bit Reflectivity products are very useful in detecting boundaries
   b) The product should be used for identifying storm structure features such as WERs, BWERs, and hook echoes.
   c) The product comes in 8 or 16 data levels depending on settings at the RPG HCI.
   d) Several elevation cuts are needed for proper storm evaluation.

Answer: a, b, d are all True. C is false since the 8-bit product only comes in 256 data levels and is not changeable.

3. **True/False** Forest fires, chaff and other non-meteorological phenomena will be observed on the Base Products at times, but only while operating in VCPs 21 and 121.

Answer: False. All these things can be seen in all VCPs. They tend to show up better in the Clear Air Mode VCPs 31, 32.

4. To attempt mitigation of Range Folding the radar operator can:
   a) Adjust the PRF
   b) Invoke Clutter Suppression
   c) Select a higher elevation slice
   d) Switch to VCP 121
   e) All the above

Answer: All the above. Each action will have varying degrees of success.

5. Which of these statements concerning 8-bit Velocity products is **false**?
   a) Range folding may obscure data at times.
   b) The resolution of the 8-bit Velocity product is .13 nm resolution, with a range of 124nmi.
   c) Velocities will not be improperly dealiased, except around strong mesocyclones

and TVSs.
d) The product is useful in estimating ground relative wind speeds.

Answer: C. Velocities can be improperly dealiased for several reasons which can lead to bad data in a number of places, not just near mesos and TVS's.

6. A bow echo is observed 35 nm west of the RDA and is moving east. You are investigating 8-bit Velocity products for a possible wind maximum that may produce surface straight-line wind damage. However, range folding is observed on the 0.5 degree products. You are currently in VCP 11. Of the following, which is the best action to take to display reliable velocity data?
a) Change the velocity data levels at the RPG HCI after gaining approval through the unit radar committee.
b) Use the .54 nm Base Velocity product.
c) Send a one-time request for a Base Spectrum Width product.
d) Switch to VCP 21.
e) Switch to VCP 121.

Answer: E. Switching to VCP 121 should minimize both range folding and improperly dealiased velocities. "A" will have no effect as you are only changing the number of data levels; "B" is also incorrect as the same problem will exist in all velocity products at the same location. "C" incorrect as you are not getting velocity data per se and even if you were, range folding would impact in the same area. "D" incorrect as switching to VCP 12 will do little to impact rangefolding.

7. The Spectrum Width product can be used to:
   a) Evaluate the validity of the mean radial velocity estimates.
   b) Help locate boundaries
   c) Locate areas of suspected turbulence
   d) Detect chaff only when operating in VCP 12 and 121.
   e) Calculate rotational velocities in tornadic thunderstorms.

Answer: A-D. You would NOT use SW for calculating velocities (rotational or otherwise) in any situation. SW is a measure of the reliability of the velocity estimates.

8. **True/False.** Areas of range folding on velocity products will also be range folded on Spectrum Width products.
True. Since SW is a measure of the accuracy of the velocity estimates, if there are no velocity estimates depicted due to range folding, there are spectrum width values displayed

8/05

Review Exercises
Reflectivity Derived Products

Instructions: Select the most correct answer. Questions 8-11 require the figures provided.

1. True or False   Cell-Based VIL will *usually* be more accurate than Grid VIL for a fast moving storm.

2. Which of the following statements about the Composite Reflectivity product is true?

   a) The height of the maximum reflectivity for each resolution grid box is known.
   b) The product is useful for locating hook echoes, when present with a storm.
   c) Echo aloft can not be discriminated from precipitation reaching the surface.

3. The Enhanced Echo Tops product

   a) uses 256 data levels.
   b) uses the beam center point for the height calculation.
   c) requires you to have the DVIL product on the RPS list in order to generate it.

4. True or False   The value of the ULR product is that you can choose a layer which highlights an area of interest, such as the altitude of the bright band.

5. When examining a thunderstorm, one strength of the Reflectivity Cross Section product is:

   a) to estimate storm top divergence.
   b) the combined attribute table is available.
   c) to evaluate the height of higher dBZ's.

6. The Layer Composite Reflectivity Maximum *mid-level* product will often be useful in determining:

   a) The location of BWERs when present.
   b) echo development aloft.
   c) the max dBZ in a storm.

7. Which of the following products may be effective for detecting storms with $\geq$ 3/4 inch hail? (More than one answer possible).

   a) Hail Index
   b) Enhanced Echo Tops
   c) Vertically Integrated Liquid
   d) Reflectivity Cross Section
   e) Layer Composite Reflectivity Maximum
   f) Composite Reflectivity
   g) Storm Track

Questions 8-11 use the figures provided.

8. **True or False** A bounded weak echo region is located on the west side of the storm depicted in the cross section.

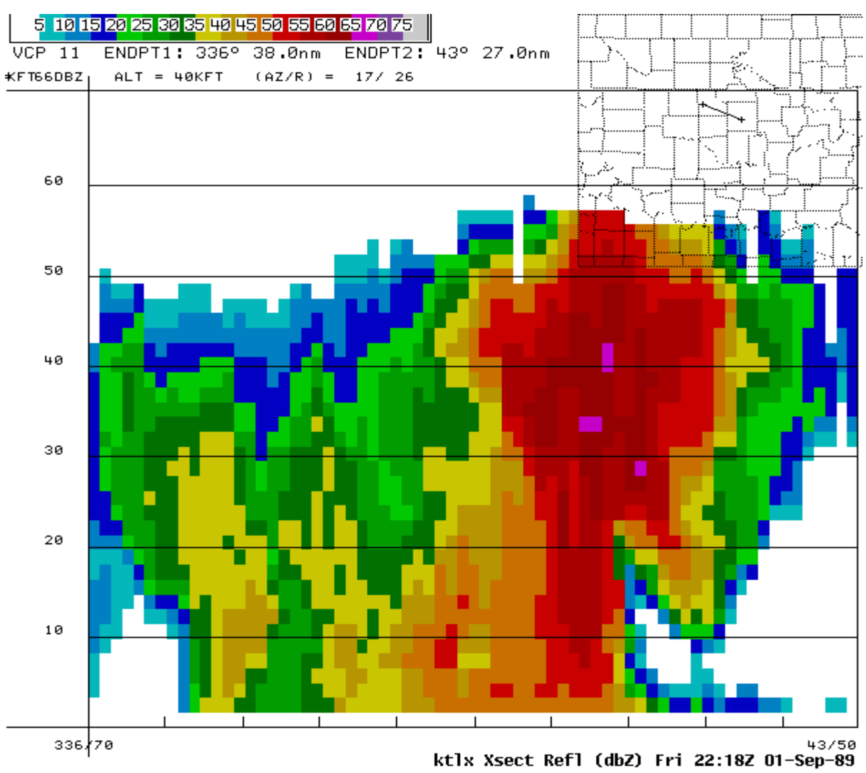


Figure 1. Reflectivity Cross Section.

9. Using the four-panel reflectivity product, this storm is exhibiting:

   a) Convergence
   b) A weak echo region.
   c) A bounded weak echo region.

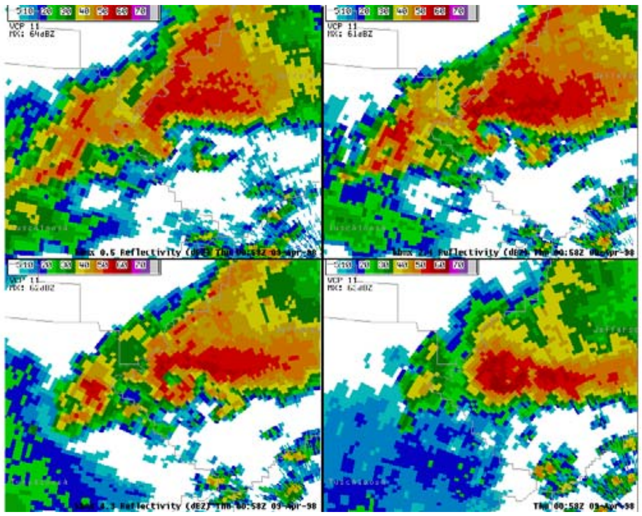


Figure 2. Four panel reflectivity centered 30 miles northwest of the RDA.

10. The narrow “spike” depicted between 30kft and 40kft on the left storm in the cross section is:

   a) A result of interpolation in the current scan strategy.
   b) A Three-Body Scatter Spike, indicative of large hail.
   c) Related to algorithm failure.

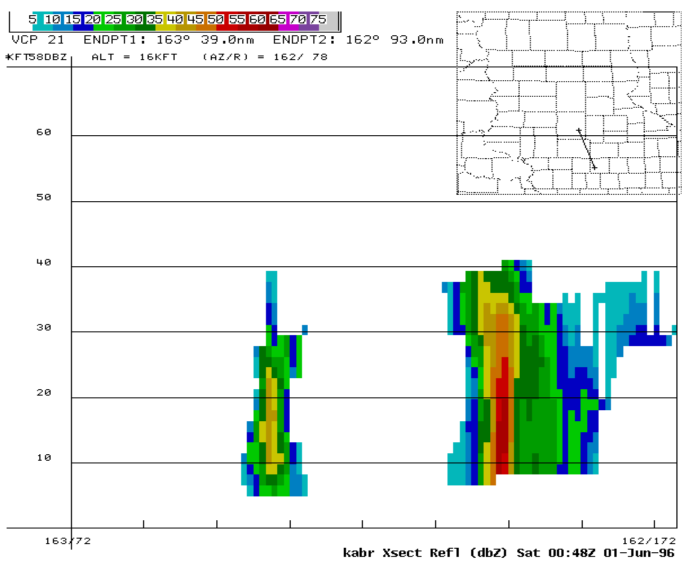


Figure 3. Reflectivity Cross Section.

11. It’s summertime in the Rockies. Thunderstorms have developed in the monsoon moisture streaming northward. On the day in question, a severe thunderstorm watch is in effect. The VIL threshold estimated on this day is approximately 45. After looking at the information provided, what kind of action would you take for the storm centered in each of the products?

a) Issue a severe thunderstorm warning.
b) Issue a tornado warning.
c) Wait for another volume scan to make a decision.
d) Wait for spotter confirmation to make a decision.

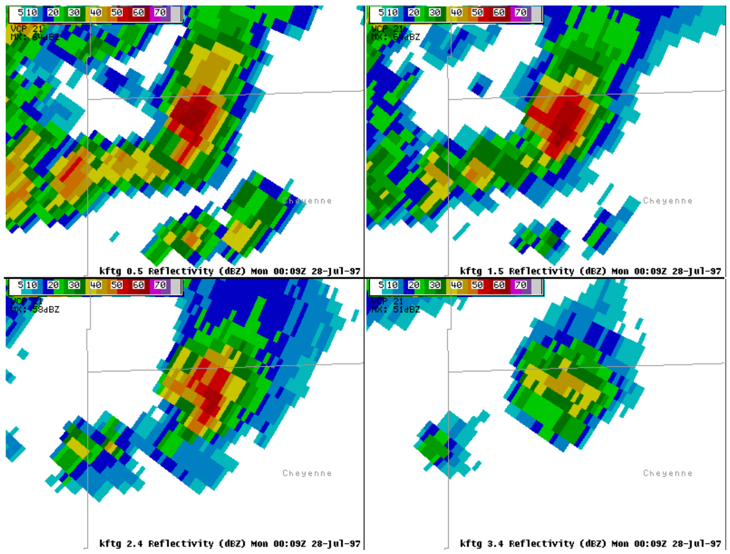


Figure 4. Four panel reflectivity product. The range to the storm is around 90nm. The altitude of 2.4 degree slice is around 28Kft. The altitude for the 3.4 degree slice is near 37Kft.

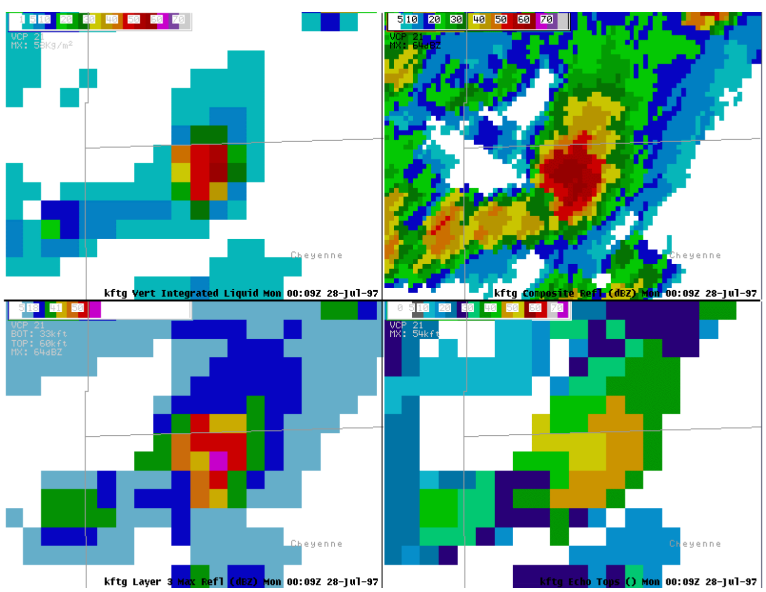


Figure 5. VIL(max 55), CR (max 60dBZ), LRM-M (max 57dBZ) and ET(max 50Kft) product for the same storm at the same time.

Review Exercises
Reflectivity Derived Products
*******ANSWERS*******

Be sure to check each answer if you are not sure why they are wrong or right.

1. True or False   Cell-Based VIL will *usually* be more accurate than Grid VIL for a fast moving storm.
   The answer is TRUE. Remember that Cell-Based VIL will attempt to identify the cell even when the upper components are not vertically stacked. Grid VIL will likely underestimate the storm as the upper components will fall in grid boxes adjacent to those for the lower components. This is due to the continued motion of the storm during the time it takes to complete the volume scan.

2. Which of the following statements about the Composite Reflectivity product is true?
   a) The height of the maximum reflectivity for each resolution grid box is known.
   No way! This is one of the limitations of the CR product. You do NOT know from what elevation angle each reflectivity value comes.

   b) The product is useful for locating hook echoes, when present with a storm.
   Egad! This is NOT where you want to look for hook echoes or pendants. It would be a misapplication of this product (kinda like using a toaster to make Jell-O - nothing wrong with the toaster...except if you're using it to make Jell-O!) In a CR product, the echo overhang often masks the hook echo. You would therefore refer back to a Base Reflectivity product for this feature.

   hh) Echo aloft can not be discriminated from precipitation reaching the surface.
   Very true! This is why you don't want to use this product to brief anyone on where it may or may not be raining. Echo aloft (such as cirrus anvil) may look exactly like light rain. Comparing the CR to a Base Reflectivity product will help make this discrimination.

3. The Enhanced Echo Tops product

   a) uses 256 data levels.
   Correct!

   b) uses the beam center point for the height calculation.
   No it interpolates.

   c) requires you to have the DVIL product on the RPS list in order to generate it.
   No. The EET product is produced separately.

4. True or False   The value of the ULR product is that you can choose a layer

which highlights an area of interest, such as the altitude of the bright band.

True. You can choose any depth so long as the thickness is at least 1kft.

5. When examining a thunderstorm, one strength of the Reflectivity Cross Section product is:

a) to estimate storm top divergence.

Negative. You need velocity to estimate divergence. This will be an application of the Velocity Cross Section to be discussed later.

b) the combined attribute table is available.

No. Sometimes people will confuse the names of the Reflectivity Cross Section and the Composite Reflectivity (which *does* have an attribute table with it). If you picture the RCS, you will likely remember that this is *not* where you find the Combined Attribute Table.

<u>c) to evaluate the height of higher dBZ's.</u>

Yes! You must be careful with the placement of the cross section line through the storm, but you can use the resulting RCS to evaluate the height of the 50 dBZ core, for example.

6. The Layer Composite Reflectivity Maximum *mid-level* product will often be useful in determining:

a) The location of BWERs when present.

No! Any BWER which is present in mid levels will likely be masked by higher reflectivity echo above the BWER in that layer. Just as the CR product is not the place to look for signatures such as pendants and hook echoes, the LRM, which basically uses the same process, should also not be used for this purpose.

<u>b) echo development aloft.</u>

Yes! A great application of this product is with elevated convection. You can often see the mid-level development on this product before anything shows up at the surface. This could lead to valuable lead-time for pulse thunderstorms in the summertime.

c) the max dBZ in a storm.

Close! You can see the max dBZ in that *layer*, but you would have to check all three layers to determine the max in the storm.

7. Which of the following products may be effective for detecting storms with ≥ 3/4 inch hail? (More than one answer possible).

a) Hail Index - ***make sure environmental data is representative***
b) Enhanced Echo Tops - ***consider the effects of scan strategy on values***
c) Vertically Integrated Liquid - **“*significant” values change with environment***
d) Reflectivity Cross Section - ***how well you see storm depends on the cut taken***

e) Layer Composite Reflectivity Maximum - ***mid/high level, depends on environment***
f) Composite Reflectivity - ***shows max in storm, but you don't know what height***
g) Storm Track - ***could infer something from the attribute table readout which shows the max dBZ and its height***
Answer: Each of these can be effective *when used properly* in the decision making process. You will want to keep in mind the strengths and limitations of each (some of which are listed above), in conjunction with sampling limitations, and be sure to use them with other products. Keep in mind that the lack of convincing evidence on any one product could be a result of these limitations, rather than an actual representation of the storm.

8. **True or <u>False</u>** A bounded weak echo region is located on the *west* side of the storm depicted in the cross section.
False! This is sort of a 2-part question: 1)Do you recognize a BWER, and 2) Can you tell what orientation the cross section samples the storm? Both are important. The cross section does show a BWER, however it is on the *east* side of the storm. Remember that the origin of a cross section is the western-most point, unless the line is along the same longitude - in which case the origin is the northern-most point.

9. Using the four-panel reflectivity product, this storm is exhibiting a:
a) Convergence
It may well have convergence but we'd need a velocity product to see this.

b) Weak echo region.
Yes but "c" is probably a better answer.

c) Bounded weak echo region.
Yes! In a four panel, the BWER will show up as a "donut". The storm exhibits a hook in quadrant 1 , almost a complete BWER in quadrant 2, and a definite BWER (donut) in the 3rd (lower left) quadrant.

10. The narrow "spike" depicted between 30kft and 40kft on the left storm in the cross section is:
<u>a) A result of interpolation in the current scan strategy.</u>
Yes. The cross section process interpolates from one elevation cut to the next higher cut where data are detected. This cross section obviously went through two pixels of reflectivity at the higher slice (looks like it was around 5dBZ). It then had to interpolate between that pixel and whatever was below it on the previous slice. This is indeed an artifact of the interpolation process when used with discrete elevation sampling.

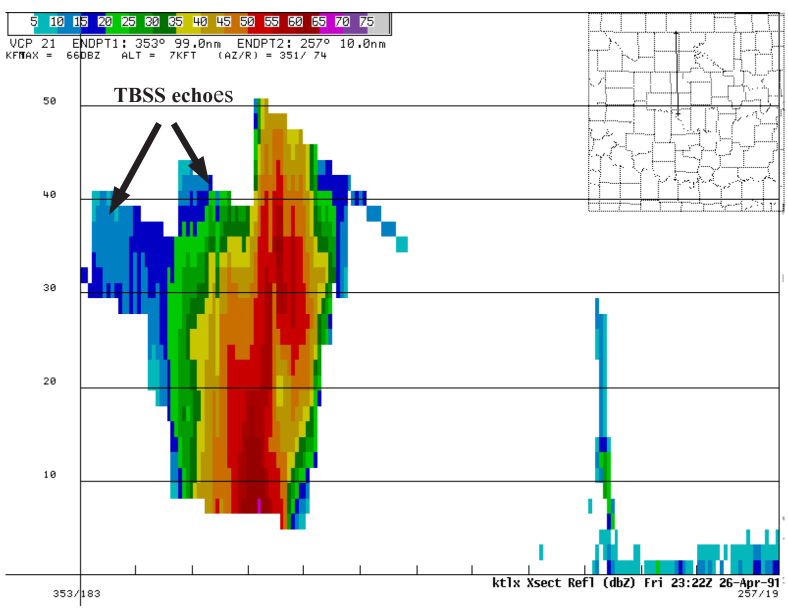
b) A Three-Body Scatter Spike, indicative of large hail
No. This is not a three-body scatter spike. The cross section process

interpolates from one elevation cut to the next higher cut. This cross section obviously went through two pixels of reflectivity at the higher slice (looks like it was around 5dBZ). It then had to interpolate between that pixel and whatever was below it on the previous slice This is indeed an artifact of the interpolation process.

For an example of a TBSS, look at figure the figure below. This on the other hand, is a three-body scatter spike as shown in a cross section. The TBSS is the weak reflectivities which extend *down-radial* from the high reflectivity core.

c) Related to algorithm failure

No - the algorithm did what it was suppose to do and that is interpolate between elevation cuts. The cross section process interpolates from one elevation cut to the next higher cut. This cross section obviously went through two pixels of reflectivity at the higher slice. It then had to interpolate between that pixel and whatever was below it on the previous slice. This is indeed an artifact of the interpolation process.



11. It's summertime in the Rockies. Thunderstorms have developed in the monsoon moisture streaming northward. On the day in question, a severe thunderstorm watch is in effect. The VIL threshold estimated on this day is approximately 45. After looking at the information provided, what kind of action would you take for the storm centered in each of the products?

a) Issue a severe thunderstorm warning.
b) Issue a tornado warning.
c) Wait for another volume scan to make a decision.
d) Wait for spotter confirmation to make a decision.

Considerations: The four panel shows 50-55dBZ extending up at least to 28kft or higher. The LRM-M indicates at least 57 dBZ somewhere in the layer between 24-36kft. The VIL is above your threshold of 45 (for 3/4 inch hail) but it is at a fairly long range and may be slightly overestimated. The CR product is detecting 60dBZ although it doesn't show up in any of the 4 slices in the 4-panel.

Warning Decision:
Issue a SVR: If you were to issue an SVR, it should be now (or maybe a while ago). Otherwise, you will have no lead time. The vertical extent of the high reflectivity core is significant enough that you would expect fairly large hail (considering the time of year and the environment). This is supported by the VIL values as well as the size of the core as represented by the VIL product. All the other product input supports this as well. Sampling limitations seem to be having a minimal impact on the storms presentation.

Issue a TOR: This is a possibility. However, as far as a tornado warning goes, what *information provided here* would support this decision? Probably very little.

Wait for another volume scan: You could also do this. If you choose to wait, you should have in mind what it is you're waiting to see which will cause you to warn. Frankly, we've seen enough.

Wait for spotter input: You could also do this. Something to keep in mind is what kind of input would you want to hear that would cause you to issue a warning (and still have positive lead time.) Also remember there are times and places where spotter reports are few and far between...don't wait on them if other inputs are convincing.

What happened: There is no right or wrong answer. There are however, good decisions which will stand up to any scrutiny, regardless of the outcome, and bad decisions which may be based on erroneous information or logic. A good decision here is one based on the proper use of all the information provided, including the strengths and limitations of the products as well as the radar. This storm had a history of producing golfball hail and would produce nickel size hail shortly.

8/05

Worksheet
Reflectivity Derived Products

The following questions pertain to Reflectivity Derived Products. Answer them if you desire a little extra practice. The answers are included at the end of the worksheet.

1. A thunderstorm moving at 45 mph has a Grid VIL considerably lower than the threshold you estimated earlier in the day. You get reports of quarter size hail. Can you explain? **Note: The airmass has not changed appreciably.**

2. A storm which you have classified as a "mini supercell" is currently producing a tornado. The DVLs with it are less than 25kg/m^2. Why?

3. The Cell-Based VIL (associated with the "main" cell of a very large storm complex 20 miles away from the RDA) has apparently decreased dramatically this volume scan. At the same time, the Grid VIL has remained high and fairly constant. Any explanation?

4. In what instances might the Cell-Based VIL be higher than the Grid VIL for a particular storm?

5. How are critical VIL thresholds (values which correlate with 3/4 inch hail) estimated on a given day?

6. Why are the VIL values sometimes unreliable beyond 100nm?

7. Why would thresholds established with the VIL product not necessarily be applicable to the DVL product?

8. A member of the local media calls you up to say he's using the information on the Composite Reflectivity attribute table to locate a TVS listed there. However, at the AZ/RAN listed, he sees no evidence of a circulation. Is this TVS a false alarm?

9. What two radar limitations cause the bases and tops of echoes in cross sections to be truncated?

10. While cross sections can show storm structure and the depth of the reflectivity core, why will they likely not be the primary tool for investigating storms in real time?

11. Why would you not expect to see hook echoes on a Composite Reflectivity?

12. What product allows you to depict a reflectivity layer with thickness of your choice anywhere from 0 to 70kft?

13. Why do the tops on the Enhanced Echo Tops product vary from the storm cell tops from the SCIT Algorithm?

Worksheet
Reflectivity Derived Products...ANSWERS!

1. A thunderstorm moving at 45 mph has a Grid VIL considerably lower than the threshold you estimated earlier in the day. You get reports of quarter size hail. Can you explain? **Note: The airmass has not changed appreciably.**

It could be that the storm speed is the culprit. Fast moving storms cause reflectivity on higher tilts to be spread to adjacent grid boxes. This will be more pronounced in VCP 21, 121 in faster moving storms since it takes a minute longer.

2. A storm which you have classified as a "mini supercell" is currently producing a tornado. The DVLs with it are less than 25kg/m^2. Why?

A mini supercell is by definition low topped. The reflectivity core does not have great vertical extent. DVIL (being a measure of the vertical extent of reflectivity)will be correspondingly low. This is why VIL and DVIL can be helpful for pointing to storms with deeper reflectivity cores, but not necessarily for storms which are significant for other reasons (high winds, shear, rotation).

3. The Cell-Based VIL (associated with the "main" cell of a very large storm complex 20 miles away from the RDA) has apparently decreased dramatically this volume scan. At the same time, the Grid VIL has remained high and fairly constant. Any explanation?

Often large storms will have several "cells" identified with them. This may cause components to be mis-assigned when these cells are in close proximity. In this case, an adjacent cell probably got the components previously assigned to the "main" cell. The result may be that cell based output may be adversely affected.

4. In what instances might the Cell-Based VIL be higher than the Grid VIL for a particular storm?

If a storm is fast moving or strongly tilted, it can retain more of its definition in the Cell-Based VIL (assuming it has been correctly identified by the algorithm) while in the Grid VIL, upper and lower cores may end up in adjacent grid boxes.

5. How are critical VIL thresholds (values which correlate with 3/4 inch hail) estimated on a given day?

The operator must consider the environment, make an estimate, and then verify it with ground truth. There may be other ways (possibly relating the Wet-Bulb Zero or using VIL Density), but they too should use ground truth to verify. Keep in mind that any value on a VIL product can be inferred sooner by looking at an alltilts of reflectivity.

6. Why are the VIL values sometimes unreliable beyond 100nm?

The algorithm assumes the dBZ values at 0.5 degrees extend down to the radar height. This may cause mid and high topped storms to have overestimated VILs, and low-topped convection to have underestimated VILs.

7. Why would thresholds established with the VIL product not necessarily be applicable to the DVL product?

The DVL Product has a .54nm spatial resolution (compared with the 2.2nm of the VIL) and uses 256 data levels (compared with 16). The DVL also does not cap the reflectivity input at 55 dBZ like the VIL product does. This can result in significantly higher DVL values (in some cases).

8. A member of the local media calls you up to say he's using the information on the Composite Reflectivity attribute table to locate a TVS listed there. However, at the AZ/RAN listed, he sees no evidence of a circulation. Is this TVS a false alarm?

The azimuth and range listed on the Composite Reflectivity Combined Attribute Table (to which this user has access), is that of the *storm cell* whose ID is listed on the table. That AZ/RAN, which comes from the SCIT algorithm, is the location of the cell's 3-D center of mass, not the location of any TVS or MESO which may be associated with the storm. In order to locate the AZ/RAN of any TVSs (and there may be more than one) which are "associated" with this storm, one must look at the TVS product (which this user does NOT have access to.) In this case, all anyone can tell by looking at the CR attribute table is that there is at least 1 TVS detected during this volume scan that was given the ID of the storm listed.

9. What two radar limitations cause the bases and tops of echoes in cross sections to be truncated?

Bases will be truncated due to the radar horizon effects.
Tops will be truncated due to scan strategy effects.

10. While cross sections can show storm structure and the depth of the reflectivity core, why will they likely <u>not</u> be the *primary* tool for investigating storms in real time?

It can be hard to get placement just right. It also takes time and is always from the previous volume scan.

11. Why would you not expect to see hook echoes on a Composite Reflectivity?

Echo overhang will usually obliterate it.

12. What product allows you to depict a reflectivity layer with thickness of your choice anywhere from 0 to 70kft?

User Selectable Layer Reflectivity Maximum (ULR)

13. Why do the tops on the Enhanced Echo Tops product vary from the storm cell tops from the SCIT Algorithm?

The EET product uses the height of the 18.3 dBZ echo. The Storm/Cell Top uses the height of the highest component (at least 30 dBZ).

8/05

Review Exercises
SCIT Products and Displays

Instructions: Select the most correct answer.

1. Which of the following statements about the Storm Track Information Product is **true**?

   a) Right turning storms will be indicated by a curved forecast track.
   b) Past positions will be plotted in volume scan intervals.
   c) The movement of hurricanes will be well tracked.

2. Which of the following statements is **true** about the Storm Track Information Product?

   a) The product can only be used as an overlay on volume products.
   b) Lines of storms will usually treated as a single cell.
   c) Storm cells in close proximity to one another may have erroneous attributes.

3. True/False The Hail product no longer takes into account the environment.

4. A forecast office observes thunderstorms ahead of a cold front in the warm sector, and other ones deep in the cold air behind the front. The Hail Temperatures Data was input during the morning before the front went through. What will the Hail Product likely do with the storms in the **cold sector**?

   a) Overestimate the actual hail size.
   b) Underestimate the actual hail size.
   c) Have no effect on the estimated hail size.

Review Exercises
SCIT Products and Displays
******ANSWERS******

Be sure and look at all answers if you are not sure why they are right or wrong.

1. Which of the following statements about the Storm Track Information Product is **true**?

   a) Right turning storms will be indicated by a curved forecast track.
   No. Forecast tracks will always be indicated with a straight line. If a storm's past track indicates it is turning, the user should mentally adjust the forecast positions to account for this.

   b) Past positions will be plotted in volume scan intervals.
   Yes. Up to 10 volume scans of past positions will be displayed. A storm whose centroid is deviating will have this represented in the past tracks.

   c) The movement of hurricanes will be well tracked
   While individual cells within the hurricane may be tracked pretty well, the overall movement of the hurricane will not be.

2. Which of the following statements is **true** about the Storm Track Information Product?

   a) The product can only be used as an overlay on volume products.
   No. Actually you can overlay the STI on any other geographic product (volume or base). The problem is that they must be from the same volume scan, i.e the times must match. This is why when you get a newly arriving Base Reflectivity, for example, and try to overlay the STI on it, it will not display (it has not been generated yet for that volume scan).

   b) Lines of storms will usually treated as a single cell.
   No. The SCIT algorithm will define areas of higher reflectivities within the line as individual cells. It will also usually break apart large core storms as they get closer to the RDA.

   c) Storm cells in close proximity to one another may have erroneous attributes..
   Yes! Because the SCIT algorithm tries to separate out individual cells in a cluster of cells, it will occasionally mismatch low and higher level components. For instance, a cell which previously was identified to 40Kft may have its top half assigned to a nearby cell in the next volume scan. Imagine what this would do to the Cell Trend information for both of these cells!

3. True/False The Hail product no longer takes into account the environment.

   The answer is False! It does attempt to account for changes in the environment by using the height of the 0 degree and -20 degree isotherms (input at the ORPG HCI).

4. A forecast office observes thunderstorms ahead of a cold front in the warm sector, and other ones deep in the cold air behind the front. The Hail Temperatures Data was input during the morning before the front went through. What will the Hail Product likely do with the storms in the **cold sector**?

   a) Overestimate the actual hail size.

      No - just the opposite. Imagine the freezing level was at 12Kft in the morning, and is now down to 4Kft. The height of the -20 degree isotherm has also dropped a few thousand feet. The algorithm checks to see how far above the freezing level (and how far above the height of the -20 degree isotherm) the 40-50dBZ core is. It will obviously underestimate these depths if still using the data from the morning sounding. This will lead to an underestimation of the hail size in this cold sector.

   b) Underestimate the actual hail size.

      Yes! Imagine the freezing level was at 12Kft in the morning, and is now down to 4Kft. The height of the -20 degree isotherm has also dropped a few thousand feet. The algorithm checks to see how far above the freezing level (and how far above the height of the -20 degree isotherm) the 40-50dBZ core is. It will obviously underestimate these depths if still using the higher altitudes from the morning sounding. This will lead to an underestimation of the hail size in this cold sector.

   c) Have no effect on the estimated hail size.

      It will likely have an effect, which could be substantial depending on how drastic a change has taken place. Imagine the freezing level was at 12Kft in the morning, and is now down to 4Kft. The height of the -20 degree isotherm has also dropped a few thousand feet. The algorithm checks to see how far above the freezing level (and how far above the height of the -20 degree isotherm) the 40-50dBZ core is. It will obviously underestimate these depths if still using the higher altitudes from the morning sounding. This will lead to an underestimation of the hail size in this cold sector.

8/05

Worksheet
Storm Cell Algorithms and Products

The following pertain to the SCIT algorithm and products. Answer them if you desire a little extra practice. The answers are included at the end of the worksheet.

1. Which VCP will generally give more representative output of derived products, especially within 60nm of the radar?

2. Who has the authority to make changes to the 7 reflectivity thresholds used to identify storm cells in the SCIT algorithms?

3. a. What environmental data must be set for the Hail Detection Algorithm to be representative?

   b. How often should this information be updated?

   c. Whose responsibility is it to do so?

4. Where can you adjust the number of storms to be displayed from the Storm Track Product?

5. The cell-based VIL of a storm appears to be diminishing as the storm approaches the radar. What non-meteorological reason could there be to explain this?

Storm Cell Algorithms and Products....ANSWERS!!

1. Which VCP will generally give more representative output of derived products, especially within 60nm of the radar?

   VCP 12 - Less gaps and better resolution at lower levels.

2. Who has the authority to make changes to the 7 reflectivity thresholds used to identify storm cells in the SCIT algorithms?

   ROC

3. a. What environmental data must be set for the Hail Detection Algorithm to be representative?
   Heights of the 0 degree and -20 degree isotherms.

   b. How often should this information be updated?
   At least twice a day, or as often as necessary to reflect environmental conditions.

   c. Whose responsibility is it to do so?
   The local office with RPG HCI control.

4. Where can you adjust the number of storms to be displayed from the Storm Track Product?
   These values, as well as those impacting output from the Hail Algorithm, TVS display, and SRM default motion, and others, can be found via the Icon Graphic Controls in the "Radar" menu on AWIPS.

5. The cell-based VIL of a storm appears to be diminishing as the storm approaches the radar. What non-meteorological reason could there be to explain this?
   The storm with which the cell-based VIL is associated is probably being impacted by the cone of silence as it gets closer to the radar. This means less and less of the storm is being sampled. All cell-based attributes, not just cell-based VIL, will be impacted by this.

8/05

REVIEW EXERCISES
Velocity Derived Products

Instructions: Select the most correct answer. Question 12 uses the supplied figure. Answers are attached. No peeking allowed.

1. When the ground-relative winds are important, what should be used?

   a) 8-bit Base Velocity
   b) 8-bit SRM with the average motion of all storms
   c) 8-bit SRM with the motion of the storm in question

2. What product must be in the database in order to generate an 8-bit SRM product display?

   a) 4-bit SRM product
   b) 8-bit Base Velocity
   c) VAD
   d) You don't need any special product to view the 8-bit SRM.

3. If a Velocity Cross Section is generated along a radial, the operator can evaluate the __ .

   a) strength of a circulation
   b) depth of a mesocyclone
   c) the strength of the storm top divergence

4. **True or False** The VAD algorithm needs at least 180 degrees of data before it will fit a sine wave to the data points.

5. Which of the following statements concerning the Mesocyclone Detection (MD) product is true?

   a) There is no attempt at time continuity.
   b) Any circulation with a strength rank of 5 or more is classified as a mesocyclone.
   c) Mesocyclones will only be detected in SCIT identified storms.

6. **True or False** The TDA algorithm only searches identified mesocyclones for the occurrence of a TVS or ETVS.

7. Which of these is true about the TDA algorithm and TVS product?

a) Isolated severe convection will usually produce more false alarm detections than squall line situations.
b) TVS detections represent gate-to-gate shear signatures.
c) Identified TVSs will always have their bases on the lowest elevation angle.

8. One strength of the VAD Wind Profile is to display the:

a) strength of a low level jet.
b) symmetry error.
c) sine wave curve.

9. Which of these products are you likely to investigate to help you evaluate the strength and depth of mesocyclones?

a) VAD
b) 8-bit Velocity
c) 8-bit SRM

10. True/False One feature of the Mesocyclone Detection (MD) product is the cursor readout which reveals attributes of the feature being sampled.

11. Which of the following can be said of the Tornado Detection Algorithm Rapid Update Product?

a) The product is generated once per volume scan.
b) The product is generated once per elevation slice.
c) The product is only available as a once time request.

Question 12 uses the figure provided.

12 Using figure 1, the winds appear reasonably accurate in the 10,000 - 15,000 ft range since __ .

a) the symmetry is near zero
b) the RMS error is low
c) there are only a few "ND" points

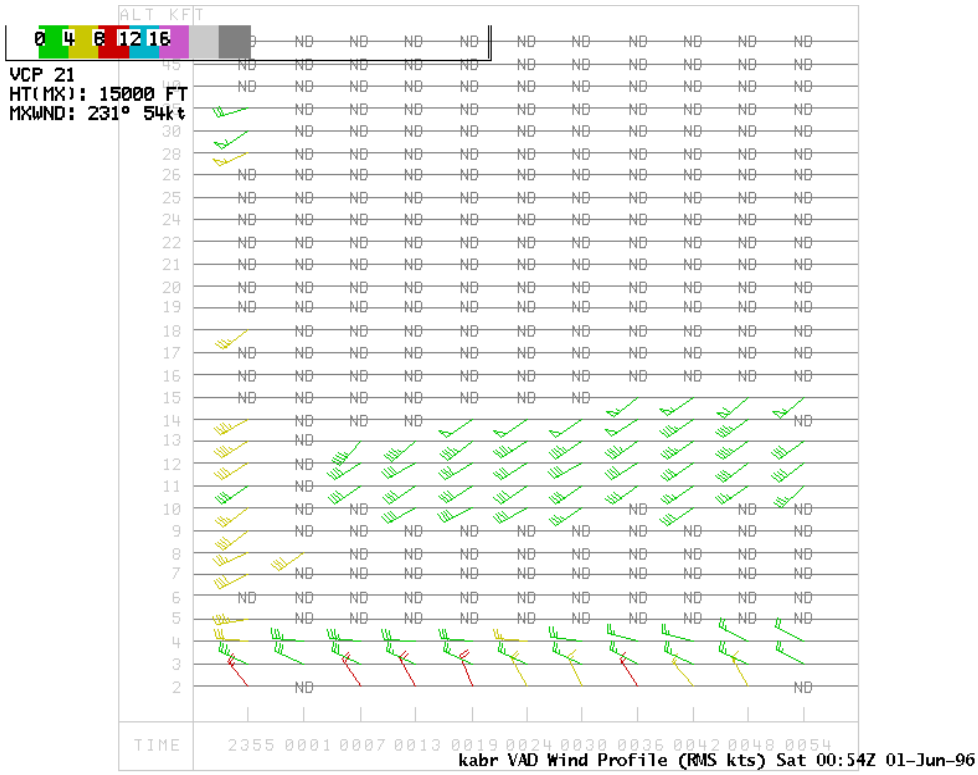


Figure 1. VAD Wind Profile.

REVIEW EXERCISES
Velocity Derived Products
******ANSWERS******

Be sure and check the reasoning for each answer if you're not sure why each is wrong or right.

1. When the ground-relative winds are important, what should be used?

   a) 8-bit Base Velocity
   Absolutely! If looking for the strength of gradient winds or the strength of a gust front, you want *ground relative* winds (no storm motion subtracted out). All the Base Velocity products are ground relative by definition. The higher the resolution you can use, the more complete the information will be.
   b) 8-bit SRM with the average motion of all storms
   No. You don't want motion subtracted if you are trying to determine ground relative winds.
   c) 8-bit SRM with the motion of the storm in question
   No. You still don't want motion subtracted if you are trying to determine ground relative winds.

2. What product must be in the database in order to generate an 8-bit SRM product display?

   a) 4-bit SRM product
   b) 8-bit Base Velocity
   This is the correct answer. The 8-bit SRM is NOT a product produced by the RPG. It is a *display* that AWIPS creates on the fly using the 8-bit Base Velocity product.
   c) VAD
   d) You don't need any special product to view the 8-bit SRM.

3. If a Velocity Cross Section is generated along a radial, the operator can evaluate the _

   a) strength of a circulation.
   False. While you can use a VCS to estimate this, the cross section needs to be *perpendicular to the radial* and centered on the feature. One way to remember this is that in order to see rotation, you must see more than one azimuth, which shows inbound velocities adjacent to outbound velocities (at approximately the same range.) You do not have adjacent azimuths if

the VCS is taken down a single radial.

b) depth of a mesocyclone.

False. Just like "a". While you can use a VCS to estimate this, the cross section needs to be *perpendicular to the radial* and centered on the feature. One way to remember this is that in order to see rotation, you must see more than one azimuth, which shows inbound velocities adjacent to outbound velocities (at approximately the same range.) You do not have adjacent azimuths if the VCS is taken down a single radial.

c) the strength of the storm top divergence

Yes. A VCS taken down radial, especially through the inflow side of the storm, can allow you to infer convergence at low levels, the updraft/downdraft interface, and storm top divergence.

4. **True or False** The VAD algorithm needs at least 180 degrees of data before it will fit a sine wave to the data points.
The answer is False! The VAD algorithm need 25 data points (from 25 degrees of data) in order to make an attempt to fit a sine wave to the points. This means it can still get pretty good estimates even when there is not widespread echo. This is a strength of the algorithm.

5. Which of the following statements concerning the Mesocyclone Detection (MD) product is <u>true</u>?

a) There is no attempt at time continuity.

False. The algorithm attempts to track and forecast locations of identified features.

b) Any circulation with a strength rank of 5 or more is classified as a mesocyclone.

True. You can choose however to display only those features with a strength rank above a specified value (ranging from 1 to 5).

c) Mesocyclones will only be detected in SCIT identified storms.

False. The MDA will identify mesocyclones regardless of SCIT output.

6. **True or False** The TDA algorithm only searches identified mesocyclones for the occurrence of a TVS or ETVS.
False! The TDA algorithm returns to the base velocity data to do its processing and runs independently of the mesocyclone detection algorithm.

7. Which of these is true about the TDA algorithm and TVS product?

a) Isolated severe convection will usually produce more false alarm detections than squall line situations.

False. The algorithm usually works best with isolated severe convection.

b) TVS detections represent gate-to-gate shear signatures.

True. The algorithm is only searching gate-to-gate features.

c) Identified TVSs will always have their bases on the lowest elevation angle.

False. TVSs close to the radar can actually be on higher slices as long as they are below 600m.

8. One strength of the VAD Wind Profile is to display the:

a) strength of a low level jet.

Absolutely! This is something you can evaluate time and height wise using the VWP.

b) symmetry error.

You are probably confusing the VAD with the VWP. The VAD is where you find the sine curve, from which the algorithm calculates symmetry (the first term in the least squares equation on the bottom of the product). In contrast, the VAD Wind Profile shows the wind barbs plotted with time and height (much like the profilers).

c) sine wave curve.

You are probably confusing the VAD with the VWP. The VAD is where you find the sine curve The VAD Wind Profile shows the wind barbs plotted with time and height (much like the profilers).

9. Which of these products are you likely to investigate to help you evaluate the strength and depth of mesocyclones?

a) VAD

Not even close! Recall that the VAD works best in homogeneous wind flow situations and was not designed to diagnose small scale rotations. It can help you diagnose suspicious winds on the VWP. However, it will tell you nothing about a small scale feature such as a Meso.

b) 8-bit Velocity

This is not a bad choice, especially if you have a lot of experience in looking at velocity data. The problem is that without subtracting out the storm motion, it may be difficult for you to even recognize that a mesocyclone is present, much less evaluate it.

c) 8-bit SRM

This is probably better in most cases. Using a 4-panel Z/8-bit SRM or an ALLTILTS Z/8-bit SRM will enable you to have the best opportunity of analyzing mesocyclone features. (Note: to use the 8-bit SRM to evaluate these features, you need the 8-bit Velocity product on the RPS List).

10. True/False One feature of the Mesocyclone Detection (MD) product is the cursor readout which reveals attributes of the feature being sampled.

False. This is a characteristic of the Digital Mesocyclone Product (DMD).

11. Which of the following can be said of the Tornado Detection Algorithm Rapid Update Product?

    a) The product is generated once per volume scan.
    b) The product is generated once per elevation slice.
    Correct. The product is generated and available once per elevation slice as either a one time request or on the RPS list.
    c) The product is only available as a once time request.

Question 12 uses the figure provided.

12. Using figure 1, the winds appear reasonably accurate in the 10,000 - 15,000 ft range since __
    a) the symmetry is near zero.
    Not really. While the symmetry may indeed be near zero, there is no way to tell that from this product. You'd have to go to a VAD in order to see that.
    b) the RMS error is low.
    Yes! The RMS error is a measure of how well the sine curve fits the sample points. The lower it is, the better the fit. The better the fit, the more representative the wind calculated from that sine curve will be. The RMS error for these winds (which we can see via the color coding) is very low.
    c) there are only a few "ND" points.
    Sorry. Data sampled for one altitude really has nothing to do with those sampled at another altitude. You may very well have almost all altitudes showing ND, with only one or two winds being plotted. If the RMS error is low for these winds (note color table), then you can infer they are reasonable. You may simply have had no scatterers at the altitudes where you have ND.

8/05

Worksheet
Velocity Derived Products

The following pertain to the Velocity Derived Products. Answer them if you desire a little extra practice. The answers are included at the end of the worksheet.

1. What is the default storm motion for the 8-bit Storm-Relative Mean Radial Velocity Map product?

2. For the phenomena listed below, which product would be most effective? (Choose either 8-bit SRM product display, or 8-bit Velocity product.)

   a) Mesocyclones in a series of fast moving storms______________________

   b) Winds associated with a bow echo 20 miles from the RDA_____________

   c) A hurricane____

   d) Residual outflow boundaries on a summer day before convection develops____

3. How many elevation angles of an 8-bit SRM product are appropriate on an RPS List at a lan-lan site? Which angles are best?

4. What type of Velocity Cross Section orientation is necessary to examine the depth of a mesocyclone in a storm?

5. What are the possible entries you can make on the RPS list for inclusion of the TVS Rapid Update product?

6. In which situation, isolated convection or squall line, would there likely be more detections by the TVS algorithm?

7. How do you validate detections by either the Mesocyclone Detection or TVS algorithms?

8. Which product would you examine to check wind data that appears "suspicious" on the VAD Wind Profile?

9. Annotate these characteristics with either Mesocyclone Detection (MD) product or the Digital Mesocyclone Detection (DMD) for which they apply. Note: Some characteristics may apply to both, while others may apply to neither!

_____________ Available only at the end of the volume scan.

_____________ Can be found under the KXXX Graphics window.

_____________ Data are displayed in both SCAN and in the volume browser

_____________ Product is updated and displayable at each elevation slice

_____________ Algorithm only searches storms identified in SCIT.

_____________ Output only depicts cyclonic detections.

_____________ Cursor readout with each feature gives numerous attributes.

_____________ The product can display both past and future positions.

Worksheet
Velocity Derived Products
*****ANSWERS*****

1. What is the default storm motion for the 8-bit Storm-Relative Mean Radial Velocity Map product?

   Your choice of either 1) the most recent motion used by WARNGEN or the radar tools feature, 2) the average of all identified storms from the SCIT algorithm (same as the 4-bit SRM), or 3) a user supplied motion.

2. For the phenomena listed below, which product would be most effective? (Choose either 8-bit SRM product display, or 8-bit Velocity product.)

   a) Mesocyclones in a series of fast moving storms
      8-bit SRM as the storm motion would be subtracted out
   b) Winds associated with a bow echo 20 miles from the RDA
      8-bit Velocity since you want ground relative winds
   c) A hurricane
      8-bit Velocity since storm motions used in a hurricane situation are usually not representative of the particular area you are interested in.
   d) Residual outflow boundaries on a summer day before convection develops
      Probably the 8-bit Velocity, but the or 8-bit SRM could be used(depending on default motion setting).
      The 8-bit Velocity will give you ground relative winds. The 8-bit SRM will also give ground relative winds IF the default motion is set to that provided by the SCIT since no storms are identified, or it is operator set at 0deg, 0kts.

3. How many elevation angles of an 8-bit SRM product are appropriate on an RPS List at a lan-lan site? Which angles are best?
   At least 4 elevation angles (to place in a 4panel Z/SRM). The angles you choose will depend on your VCP and the range to the storms (low and high angles for storms close in, low angles for storms far out). For proper storm interrogation, you will also want to choose angles which will sample storms and low, mid, and high levels. With a lan-lan connection, you can add additional slices which would make it easier to select a variety of 4panels. For using the ALLTILTS function, you will want as many elevations cuts as you can get (preferably all).

4. What type of Velocity Cross Section orientation is necessary to examine the depth of a mesocyclone in a storm?
   To see circulation depth, you will want a VCS perpendicular to the beam, centered on the mesocyclone. (To evaluate low level convergence, updraft/ downdraft interface, and upper level divergence, you need a VCS along a radial.)

5. What are the possible entries you can make on the RPS list for inclusion of the TVS Rapid Update product?
   You can choose to receive this product at 1)All elevation slices, 2) All elevation slices at or below a certain slice, 3) Lowest “n” elevations slices, 4) at a specified angle.

6. In which situation, isolated convection or squall line, would there likely be more detections by the TVS algorithm?
   Regardless of the parameter set used, squall line convection will usually result in more algorithm detected features. Many of these will not be considered significant by the operator as they can be associated with transient shears along the gust front.

7. How do you validate detections by either the Mesocyclone Detection or TVS algorithms?
   ALWAYS refer to the base data to assess the validity of an algorithm detection. Consider its base data attributes, its location, the environment, and any input gleaned from spotters or storm history.

8. Which product would you examine to check wind data that appears "suspicious" on the VAD Wind Profile?
   If winds look funky on the VWP, you can do a one-time-request for a VAD wind at the offending altitude. You can then see the actual sample points and their relationship to the plotted sine wave.

9. Annotate these characteristics with either Mesocyclone Detection (MD) product or the Digital Mesocyclone Detection (DMD) product for which they apply. Note: Some characteristics may apply to both, while others may apply to neither!

____MD______ Available only at the end of the volume scan.

___MD, DMD__ Can be found under the KXXX Graphics window.

___DMD______ Data are displayed in both SCAN and in the volume browser

____DMD_____ Product is updated and displayable at each elevation slice.

____Neither!___Algorithm only searches storms identified in SCIT.

___MD,DMD___Output only depicts cyclonic detections.

____DMD_____ Cursor readout with each feature gives numerous attributes.

___MD,DMD___The product can display both past and future positions.

Precipitation Products and Algorithms Review Exercise

Match the Product on the right to the Product Characteristic on the left. (Some characteristics will describe more than one product, thus more than one letter may be used).

1. _____ Resolution 1.1nm x 1 degree
2. _____ Resolution 0.54nm x 1 degree
3. _____ Updated each volume scan
4. _____ Updated at the top of the hour
5. _____ 16 Data levels
6. _____ 256 Data levels
7. _____ Available as an alphanumeric product only
8. _____ can be generated for an operator specified period of time.
9. _____ commonly used in the generation of external products such as FFMP (Flash Flood Monitoring and Prediction.

A. Digital Hybrid Reflectivity (DHR)
B. Hybrid Scan Reflectivity (HSR)
C. One Hour Precipitation (OHP)
D. Three Hour Precipitation (THP)
E. Storm Total Precipitation (STP)
F. User Selectable Precipitation (USP)
G. Digital Precipitation Array (DPA)
H. Supplemental Precipitation Data (SPD)

Identify true statements below with a T and false statements with an F.

10._____ The digital Three Hour Product is used directly by RFC computers as input to the hydrologic models (NWSRFS).

11._____ Storm Total Precipitation is reset to zero after one hour of no precipitation.

12.____ Missing volume scans due to radar outages of more than 36 minutes will cause accumulations to reset to zero on all precipitation products.

13.____ The Storm Total Precipitation (STP) product is often used to monitor the total precipitation accumulation.

14.____ A default User Selectable Precipitation (USP) product is generated for 24 hours ending at 12Z.

15.____ The 16 data levels of precipitation accumulation on the OHP, THP, USP, and STP are fixed and can only be changed with approval from the Radar Operations Center (ROC).

Answer Key: Precipitation Products and Algorithms Review Exercise

Match the Product on the right to the Product Characteristic on the left. (Some characteristics will describe more than one product, thus more than one letter may be used).

1. C,D,E,F Resolution 1.1nm x 1 degree
2. A,B Resolution 0.54nm x 1 degree
3. A,B,C,E,G,H Updated each volume scan
4. D,F Updated at the top of the hour
5. B,C,D,E,F 16 Data levels
6. A,G 256 Data levels
7. H Available as an alphanumeric product only
8. F can be generated for an operator specified period of time.
9. A commonly used in the generation of external products such as FFMP (Flash Flood Monitoring and Prediction.

A. Digital Hybrid Reflectivity (DHR)
B. Hybrid Scan Reflectivity (HSR)
C. One Hour Precipitation (OHP)
D. Three Hour Precipitation (THP)
E. Storm Total Precipitation (STP)
F. User Selectable Precipitation (USP)
G. Digital Precipitation Array (DPA)
H. Supplemental Precipitation Data (SPD)

Identify true statements below with a T and false statements with an F.

10. F The digital Three Hour Product is used directly by RFC computers as input to the hydrologic models (NWSRFS).

11. T Storm Total Precipitation is reset to zero after one hour of no precipitation.

12. F Missing volume scans due to radar outages of more than 36 minutes will cause accumulations to reset to zero on all precipitation products.

13. T The Storm Total Precipitation (STP) product is often used to monitor the total precipitation accumulation.

14. T A default User Selectable Precipitation (USP) product is generated for 24 hours ending at 12Z.

15. F The 16 data levels of precipitation accumulation on the OHP, THP, USP, and STP are fixed and can only be changed with approval from the Radar Operations Center (ROC).